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REMOVAL SUPPORT TEAM 3
EPA CONTRACT EP-S2-14-01

April 14, 2016

Eric Daly, On-Scene Coordinator
U.S. Environmental Protection Agency
Response & Prevention Branch
2890 Woodbridge Avenue
Edison, New Jersey 08837

EPA CONTRACT NO: EP-S2-14-01
TDD NO: TO-0006-0064
DOCUMENT CONTROL NO: RST3-02-D-0250
SUBJECT: SITE-SPECIFIC UFP QUALITY ASSURANCE PROJECT PLAN
HOLY TRINITY CEMETERY SITE

Dear Mr. Daly,

Enclosed please find the Site-Specific UFP Quality Assurance Project Plan (QAPP) for the radiological survey and air sampling event to be conducted at the Holy Trinity Cemetery Site located in Lewiston, Niagara County, New York, from April 17 through April 29, 2016.

If you have any questions or comments, please do not hesitate to contact me at (732) 585-4413

Sincerely,

Weston Solutions, Inc.

Bernard Nwosu
RST 3 Site Project Manager

Enclosure
cc: TDD File No.: TO-0006-0064

SITE-SPECIFIC UFP QUALITY ASSURANCE PROJECT PLAN
HOLY TRINITY CEMETERY SITE
LEWISTON, NIAGARA COUNTY, NEW YORK

Prepared By:

Removal Support Team 3
Weston Solutions, Inc.
Engineering, Science, and Technology Division
Edison, New Jersey 08837

DC No.: RST3-02-D-0250
TDD No.: TO-0006-0064
EPA Contract No.: EP-S2-14-01

April 2016

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LIST OF ACRONYMS

ADR	Automated Data Review
ANSETS	Analytical Services Tracking System
AOC	Acknowledgment of Completion
ASTM	American Society for Testing and Materials
CEO	Chief Executive Officer
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
CFM	Contract Financial Manager
CO	Contract Officer
COI	Conflict of Interest
COO	Chief Operations Officer
CRDL	Contract Required Detection Limit
CRTL	Core Response Team Leader
CRQL	Contract Required Quantitation Limit
CQLOSS	Corporate Quality Leadership and Operations Support Services
CWA	Clean Water Act
DCN	Document Control Number
DESA	Division of Environmental Science and Assessment
DI	Deionized Water
DPO	Deputy Project Officer
DQI	Data Quality Indicator
DQO	Data Quality Objective
EM	Equipment Manager
EDD	Electronic Data deliverable
ENVL	Environmental Unit Leader
EPA	Environmental Protection Agency
ERT	Environmental Response Team
FASTAC	Field and Analytical Services Teaming Advisory Committee
GC/ECD	Gas Chromatography/Electron Capture Detector
GC/MS	Gas Chromatography/Mass Spectrometry
HASP	Health and Safety Plan
HRS	Hazard Ranking System
HSO	Health and Safety Officer
ITM	Information Technology Manager
LEL	Lower Explosive Limit
MSA	Mine Safety Appliances
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration

LIST OF ACRONYMS (Concluded)

OSWER	Office of Solid Waste and Emergency Response
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, Sensitivity
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PIO	Public Information Officer
PM	Program Manager
PO	Project Officer
PRP	Potentially Responsible Party
PT	Proficiency Testing
QA	Quality Assurance
QAL	Quality Assurance Leader
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RC	Readiness Coordinator
RCRA	Resource Conservation and Recovery Act
RPD	Relative Percent Difference
RSCC	Regional Sample Control Coordinator
RST	Removal Support Team
SARA	Superfund Amendments and Reauthorization Act
SEDD	Staged Electronic Data Deliverable
SOP	Standard Operating Practice
SOW	Statement of Work
SPM	Site Project Manager
START	Superfund Technical Assessment and Response Team
STR	Sampling Trip Report
TAL	Target Analyte List
TCL	Total Compound List
TDD	Technical Direction Document
TDL	Technical Direction Letter
TO	Task Order
TQM	Total Quality Management
TSCA	Toxic Substances Control Act
UFP	Uniform Federal Policy
VOA	Volatile Organic Analysis

CROSSWALK

The following table provides a "cross-walk" between the QAPP elements outlined in the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP Manual), the necessary information, and the location of the information within the text document and corresponding QAPP Worksheet. Any QAPP elements and required information that are not applicable to the project are circled.

QAPP Element(s) and Corresponding Section(s) of UFP-QAPP Manual	Required Information	Crosswalk to QAPP Section	Crosswalk to QAPP Worksheet No.
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2.4 Project Organization 2.4.1 Project Organizational Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and Certification	- Project Organizational Chart - Communication Pathways - Personnel Responsibilities and Qualifications - Special Personnel Training Requirements	2	5 6 7 8
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	- Project Planning Session Documentation (including Data Needs tables) - Project Scoping Session Participants Sheet - Problem Definition, Site History, and Background - Site Maps (historical and present)	1	9 10
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Site-Specific PQOs - Measurement Performance Criteria	3	11 12
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QAPP Element(s) and Corresponding Section(s) of UFP-QAPP Manual	Required Information	Crosswalk to QAPP Section	Crosswalk to QAPP Worksheet No.
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3.2 Analytical Tasks 3.2.1 Analytical SOPs 3.2.2 Analytical Instrument Calibration Procedures 3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4 Analytical Supply Inspection and Acceptance Procedures	- Analytical SOPs - Analytical SOP References - Analytical Instrument Calibration - Analytical Instrument and Equipment Maintenance, Testing, and Inspection	6	23 24 25
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	- Sample Collection Documentation Handling, Tracking, and Custody SOPs - Sample Container Identification - Sample Handling Flow Diagram - Example Chain-of-Custody Form and Seal	7	26 27
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QAPP Element(s) and Corresponding Section(s) of UFP-QAPP Manual	Required Information	Crosswalk to QAPP Section	Crosswalk to QAPP Worksheet No.
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QAPP Worksheet #1: Title and Approval Page

Title: Site-Specific UFP Quality Assurance Project Plan
Site Name/Project Name: Holy Trinity Cemetery Site
Site Location: Lewiston, Niagara County, New York
Revision Number: 00
Revision Date: Not Applicable

Weston Solutions, Inc.
Lead Organization

Bernard Nwosu
Weston Solutions, Inc.
1090 King Georges Post Road, Suite 201
Edison, New Jersey 08837
Email: ben.nwosu@westonsolutions.com

Preparer's Name and Organizational Affiliation

14 April 2016
Preparation Date (Day/Month/Year)

Site Project Manager: Signature

Bernard Nwosu/Weston Solutions, Inc.
Printed Name/Organization/Date

QA Officer/Technical Reviewer: Signature

Smita Sumbaly/Weston Solution, Inc.
Printed Name/Organization/Date

EPA, Region II On-Scene Coordinator (OSC): Signature

Eric Daly/EPA, Region II
Printed Name/Organization/Date

EPA, Region II Quality Assurance Officer (QAO): Signature

Printed Name/Organization/Date

QAPP Worksheet #2
QAPP Identifying Information

Site Name/Project Name: Holy Trinity Cemetery Site
Site Location: Lewiston, Niagara County, New York
Operable Unit: 00
Title: Site-Specific UFP Quality Assurance Project Plan
Revision Number: 00
Revision Date: Not Applicable

1. **Identify guidance used to prepare QAPP:**
   Uniform Federal Policy for Quality Assurance Project Plans. Refer to Laboratory Methods.

2. **Identify regulatory program:** EPA, Region II

3. **Identify approval entity:** EPA, Region II

4. **Indicate whether the QAPP is a generic or a <u>site-specific</u> QAPP.**

5. **List dates of scoping sessions that were held:** 4/13/2016

6. **List dates and titles of QAPP documents written for previous site work, if applicable:**

   Site-Specific UFP Quality Assurance Project Plan- Holy Trinity Cemetery Site, Lewiston, Niagara County, New York, dated August 6, 2015.

7. **List organizational partners (stakeholders) and connection with lead organization:**

   None

8. **List data users:** EPA, Region II (see Worksheet #4 for individuals)

9. **If any required QAPP elements and required information are not applicable to the project, then provide an explanation for their exclusion below:**

   None

10. **Document Control Number:** RST3-02-D-0250

QAPP Worksheet #3: Distribution List

[List those entities to which copies of the approved site-specific QAPP, subsequent QAPP revisions, addenda, and amendments are sent]

QAPP Recipient	Title	Organization	Telephone Number	Fax Number	E-mail Address	Document Control Number
Eric Daly	On-Scene Coordinator	EPA, Region II	(732) 321-4350	(732) 321-4350	Daly.Eric@epa.epamail.gov	RST 3-02-D-0250
Bernard Nwosu	Site Project Manager	Weston Solutions, Inc., RST 3	(908) 565-2980	(732) 225-7037	Ben.Nwosu@westonsolutions.com	RST 3-02-D-0250
Smita Sumbaly	QA Officer	Weston Solutions, Inc., RST 3	(732) 585-4410	(732) 225-7037	S.Sumbaly@westonsolutions.com	RST 3-02-D-0250
Site TDD File	RST 3 Site TDD File	Weston Solutions, Inc., RST 3	Not Applicable	Not Applicable	Not Applicable	-

QAPP Worksheet #4: Project Personnel Sign-Off Sheet

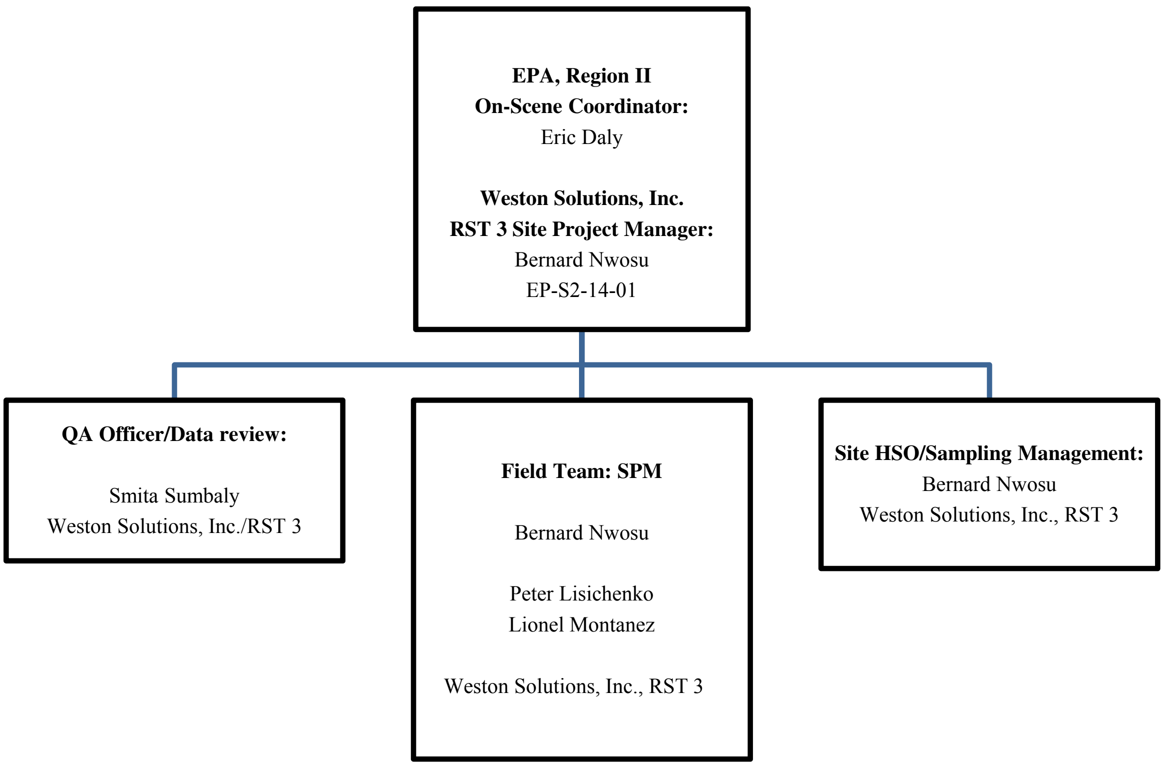
[Copies of this form signed by key project personnel from each organization to indicate that they have read the applicable sections of the site-specific QAPP and will perform the tasks as described; add additional sheets as required. Ask each organization to forward signed sheets to the central project file.]

Organization: Weston Solutions, Inc., RST 3

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Eric Daly	EPA OSC	(732) 321-4350		04/14/16
Bernard Nwosu	Site Project Manager, RST 3	(732) 585-4413		4/14/16
Smita Sumbaly	QAO, RST 3	(732) 585-4410		4/14/16
Timothy Benton	Operations Leader / HSO, RST 3	(732) 585-4425		4/14/16
Lionel Montanez	Field Personnel, RST 3	(732) 585-4436		4/14/16
Peter Lisichenko	Field Personnel, RST 3	(732) 585-4411		4/14/16

QAPP Worksheet #5: Project Organizational Chart

Identify reporting relationship between all organizations involved in the project, including the lead organization and all contractor and subcontractor organizations. Identify the organizations providing field sampling, on-site and off-site analysis, and data review services, including the names and telephone numbers of all project managers, project team members, and/or project contacts for each organization.



Acronyms:

SPM: Site Project Manager
HSO: Health & Safety Officer

QAPP Worksheet #6: Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Point of contact with EPA OSC	Acting Site Project Manager, Weston Solutions, Inc., RST 3	Bernard Nwosu, SPM	(732) 585-4421	All technical, QA and decision-making matters in regard to the project (verbal, written or electronic)
Adjustments to QAPP	Acting Site Project Manager, Weston Solutions, Inc., RST 3	Bernard Nwosu, SPM	(732) 585-4421	QAPP approval dialogue
Health and Safety On-Site Meeting	HSO, Weston Solutions, Inc., RST 3	Bernard Nwosu, SPM	(732) 585-4421	Explain Site hazards, personnel protective equipment, hospital location, etc.

OSC: On-Scene Coordinator
SPM: Site Project Manager
HSO: Health and Safety Officer

QAPP Worksheet #7: Personnel Responsibilities and Qualifications Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Eric Daly	EPA On-Scene Coordinator	EPA, Region II	All project coordination, direction and decision making.	NA
Bernard Nwosu	Field Personnel, RST 3	Weston Solutions, Inc.	Site Project Manager/ HSO / EPA point of contact	10+ Years
Peter Lisichenko	Field Personnel, RST 3	Weston Solutions, Inc.	Radiological survey and sample collection	10+ Years
Lionel Montanez	Field Personnel, RST 3	Weston Solutions, Inc.	Radiological survey and sample collection	10+Years

*All RST 3 members, including subcontractor's resumes are in possession of RST 3 Program Manager, EPA Project Officer, and Contracting officers.

QAPP Worksheet #8: Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates[1]
[Specify location of training records and certificates for samplers]						
QAPP Training	This training is presented to all RST 3 personnel to introduce the provisions, requirements, and responsibilities detailed in the UFP QAPP. The training presents the relationship between the site-specific QA Project Plans (QAPPs), SOPs, work plans, and the Generic QAPP. QAPP refresher training will be presented to all employees following a major QAPP revision.	Weston Solutions, Inc., QAO	As needed	All RST 3 field personnel upon initial employment and as refresher training	Weston Solutions, Inc.	Weston Solutions, Inc., EHS Database
Health and Safety Training	Health and safety training will be provided to ensure compliance with Occupational Safety and Health Administration (OSHA) as established in 29 CFR 1910.120.	Weston Solutions, Inc., HSO	Yearly at a minimum	All Employees upon initial employment and as refresher training every year	Weston Solutions, Inc.	Weston Solutions, Inc., EHS Database
Others	Scribe, ICS 100 and 200, and Air Monitoring Equipment Trainings provided to all employees	Weston Solutions, Inc., QAO/Group Leader's	Upon initial employment and as needed			
	Dangerous Goods Shipping	Weston Solutions, Inc., HSO	Every 2 years			

All team members are trained in the concepts and procedures in recognizing opportunities for continual improvement, and the approaches required to improve procedures while maintaining conformance with legal, technical, and contractual obligations.

[1] All RST 3 members, including subcontractor's certifications are in possession of RST 3 HSO.

QAPP Worksheet #9: Project Scoping Session Participants Sheet

Site Name/Project Name: Holy Trinity Cemetery Site
Site Location: Lewiston, Niagara County, New York
Operable Unit: 00
Date of Sessions: 4/13/2016
Scoping Session Purpose: To discuss questions, comments, and assumptions regarding technical issues involved with the sampling activities.

Name	Title	Affiliation	Phone #	E-mail Address	*Project Role
Eric Daly	EPA OSC	EPA, Region II	(732) 321-4350	Daly.Eric@ epa.epamail.gov	OSC
Bernard Nwosu	Site Project Manager	Weston Solutions, Inc., RST 3	(908) 565-2980	ben.nwosu@ westonsolutions.com	Site Project Management/ QA Officer/ Technical Reviewer
Timothy Benton	HSO	Weston Solutions, Inc., RST 3	(732) 585-4425	tim.benton@ westonsolutions.com	Health and Safety

Comments/Decisions: As part of the Removal Assessment of the Holy Trinity Cemetery Site (the Site), Weston Solutions, Inc., Removal Support Team 3 (RST 3) has been tasked with providing support to the U.S. Environmental Protection Agency (EPA) for a ground radiological survey and subcontracting a National Radon Proficiency Program (NRPP)-certified company to conduct radon sampling in a residential property adjacent to the Site. The radiological survey is being conducted to determine if radiation-containing materials are present on the property. The radon sampling is being conducted to determine the presence or absence of radon in living spaces within the property. The radiological survey will be conducted using a Ludlum-2241, Fluke Pressurized Ionization Chamber (PIC) Model 451P, Reuter-Stokes RSS-131ER High Pressure Ion Chamber (HPIC) gamma survey meters, and BNC SAM 940 portable radioisotope identification system. The radon specialist from the NRPP-certified company will provide field support in identifying radon canister placement in up to 15 locations using guidelines set forth in the American National Standards Institute (ANSI)/ American Association of Radon Scientists and Technologists (AARST) *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings* (MAMF 2012), placing the canisters, picking up the canisters, and delivering to a private laboratory for radon analysis.

Consensus Decisions: The Removal Assessment activities are scheduled to begin on April 17, 2016 and last approximately two weeks.

Action Items: A CLP Request Form and the RST 3 Analytical Services Request Forms were submitted by RST 3 on April 12, 2016.

QAPP Worksheet #10: Problem Definition

PROBLEM DEFINITION

Uranium (half-life of 4.5 billion years) is a naturally occurring radioactive isotope, decaying primarily by alpha emission with accompanying gamma. Uranium produces several radioactive isotopes including radium-226 (Ra-226) and radon-222 (Rn-222), which have a half-life of 1,602 years and 3.8 days, respectively. Rn-222 is a radioactive isotope which naturally forms as a gas, producing several radioactive radon decay products, including polonium-218, lead-214, bismuth-214, and polonium-214.

Thorium (half-life of 14 billion years) is a naturally occurring radioactive isotope, decaying primarily by alpha emissions with accompanying gamma. Thorium produces several radioactive isotopes, including gamma emitting actinium-228 (Ac-228), lead-212 (Pb-212), bismuth-212 (Bi-212), radium-224 (Ra-224), and thoron-220 gas (Rn-220). Ra-224 and Rn-220 have a half-life of 3.6 days and 55 seconds, respectively.

The U.S. Department of Health and Human Services (HHS) Agency for Toxic Substances and Diseases Registry (ATSDR) has established that long-term exposure to gamma radiation poses a health risk and radon gases in air can buildup in the lungs with the potential to cause lung cancer after prolonged exposure.

A Removal Assessment is being conducted by EPA in a residential property adjacent to the Site to determine the presence or absence of radon in living spaces within the property building through laboratory analysis and to determine if radiation-containing materials are present on the property through radiological surveys.

SITE HISTORY/CONDITIONS

The Holy Trinity Cemetery Site (the Site) consists of an area of radionuclide contamination located at a cemetery which is approximately 31.5 acres in Lewiston, New York. The Site is owned by Holy Trinity Cemetery, which has 2.91 acres of observed contamination located in the northernmost portion of the property on a relatively flat and slightly elevated grassy field, as well as on existing roadbeds. There is one building on the Site which is utilized both as a residence and cemetery maintenance facility. The Site is bordered to the north and east by Interstate 190; to the south by another cemetery; and to the west by Robert Avenue and a residential area.

In 1978, the U.S. Department of Energy (DOE) conducted an aerial radiological survey of the Niagara Falls region and identified more than 15 properties having elevated levels of radiation above background levels. It is believed that, in the early 1960s, slag from the Union Carbide facility located on 47th Street in Niagara Falls was used as fill on the properties prior to paving. The Union Carbide facility processed ore containing naturally-occurring high levels of uranium and thorium to extract niobium. The slag contained sufficient quantities of uranium and thorium to be classified as a licensable radioactive source material. Union Carbide subsequently obtained a license from the Atomic Energy Commission (AEC), now the Nuclear Regulatory Commission (NRC), and the State of New York; however, the slag had already been used as fill throughout

QAPP Worksheet #10: Problem Definition (Continued)

the Niagara Falls region prior to licensing. Based on the original survey and subsequent investigations, it is believed that the radioactive Union Carbide slag was deposited on the Site.

In February 1980, the New York State Department of Health (NYSDOH) Bureau of Radiological Health and the Niagara County Health Department conducted a radiological survey of the Site to identify areas with elevated radioactivity resulting from the use of radioactive slag for fill on the property. The survey was conducted based on information that the slag used at the cemetery was from the same source used at two other locations in nearby Niagara Falls, which had been identified by the NYSDOH as containing elevated levels of radioactivity. During the survey, cemetery personnel showed NYSDOH a slag pile located near the caretaker's garage in the western portion of the property. Cemetery personnel stated that this slag was used as fill for the cemetery roads throughout the property.

In addition, the slag was used as fill for the base of two proposed roadbeds that extended approximately 500 to 600 feet from the caretaker's garage, northwest toward Robert Avenue. At the time of the survey, the construction of these roads had been abandoned. The underlying slag base was covered with an unknown amount of soil and was left as an open field. Using an Eberline PRM 7 radiation meter, radiological survey of the slag pile indicated gamma radiation measuring 250 microroentgens per hour (µR/hr) and along cemetery roads, gamma readings ranged from 5 µR/hr (i.e., background concentration) to 30 µR/hr. Gamma readings along the abandoned roadbeds ranged from 200 µR/hr to 400 µR/hr. Samples of the slag were collected as part of the investigation. Laboratory analyses of the samples indicated that the concentrations of isotopic uranium, isotopic thorium, radium-226, and radium-228, were significantly higher than background values.

In October 2006, the New York State Department of Environmental Conservation (NYSDEC) and the Niagara County Health Department conducted a reconnaissance of the Site. At the time, the slag pile previously observed near the caretaker's garage was no longer on the Site; the current caretaker had neither knowledge of the slag pile, nor what happened to it. The caretaker also indicated that children living nearby used this area for recreation. Since the 1980 NYSDOH site investigation, trees had grown through the abandoned slag roadbeds, pushing the slag to the surface. As part of the site visit, NYSDEC conducted a radiological survey with an Exploranium GR-135. Radiological measurements taken while walking along the roadbed indicated gamma readings ranging from 200 to 450 µR/hr at waist height (1 meter/3 feet above the ground) and at-contact reading (1 inch above the ground) ranging from 450 to 570 µR/hr. At-contact reading taken next to exposed slag near a tree was documented at 700 µR/hr. NYSDEC collected four slag samples which were analyzed for isotopic uranium and isotopic thorium via gamma-ray spectroscopy. Laboratory analytical results indicated the presence of uranium-238/234 at concentrations ranging from 114 picocuries per gram (pCi/g) to 1,664 pCi/g and thorium-232 from 114 pCi/g to 898 pCi/g.

In May 2007, NYSDEC visited the Site to identify contamination in an on-site debris pile using gamma-ray spectroscopy. During a 5-minute static survey, radium-226 was the only nuclide

QAPP Worksheet #10: Problem Definition (Continued)

identified. A similar survey conducted on one of the roadbeds confirmed the presence of thorium-232.

During a reconnaissance performed by the NYSDOH and NYSDEC in July 2013, a radiological survey of on-site roadways and along the back roadway leading off site was conducted using a pressurized ion chamber (PIC) and a sodium iodide (NaI) 2x2 detector. Measurements taken along the roadways with the PIC indicated gamma levels up to 51 µR/hr and up to 50,000 counts per minute (cpm) with the sodium iodide detector.

On December 12 and 13, 2013, the U.S. Environmental Protection Agency (EPA) contractor, Weston Solutions, Inc., Site Assessment Team (SAT) personnel collected a total of 14 subsurface soil samples and three slag samples from the Site. In order to document background conditions, soil samples were also collected from two locations suspected to be outside of the source area. At each sample location, soil samples were collected directly beneath slag material; at locations where a radioactive fill layer was not visually observed, the soil sample was collected at the equivalent depth interval. Each slag sample consisted of one single piece of slag material. The soil samples were analyzed by TestAmerica Laboratories for target analyte list (TAL) metals [Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)] via EPA SW846 Method 6010C; isotopic thorium and isotopic uranium, via DOE alpha spectroscopy Health and Safety Laboratory (HASL)-300 Method A-01-R; radium-226, radium-228, and radioisotopes, via DOE gamma spectroscopy HASL-300 Method GA-01-R. The slag samples were analyzed for isotopic thorium and isotopic uranium, via DOE alpha spectroscopy HASL-300 Method A-01-R; radium-226, radium-228, and radioisotopes, via DOE gamma spectroscopy HASL-300 Method GA-01-R. For quality assurance/quality control (QA/QC) purposes, one soil sample for TAL metals analysis was designated as a matrix spike/matrix spike duplicate (MS/MSD) sample. One rinsate blank sample was collected to demonstrate adequate decontamination of non-dedicated sampling equipment (i.e., Geoprobe® cutting shoe). Analytical results indicated concentrations of radionuclides in all the slag samples and seven soil samples, including the field duplicate, to be significantly higher than at background conditions.

On May 1, 2014, SAT personnel collected radon and thoron concentration measurements from locations on and in the vicinity of the Site. At the selected locations in background areas, above the source material, and off the source area, radon and thoron concentration measurements in pCi/L were collected with RAD7 radon detectors. The radon and thoron measurements were collected at heights of one meter above the ground surface. The measurements included uncertainty values, which were taken into account to calculate adjusted concentrations for evaluation of observed release in the air migration pathway. There were no radon or thoron concentrations that exceeded the site-specific background concentration, nor were there any adjusted concentrations that equaled or exceeded a value two standard deviations above the mean site-specific background concentration for these radionuclides in this sample type (i.e., there was no evidence of an observed release to air from Site sources).

On August 10 through 13, 2015, EPA with the support of Weston Solutions, Inc., Removal Support Team 3 (RST 3) conducted a Removal Assessment of the Site. RST 3 determined the

QAPP Worksheet #10: Problem Definition (Continued)

presence/absence of radon/thoron gases and gamma radiation through radiological surveys and delineated areas of observed contamination by comparing radiological survey measurements from suspected source areas with measurements obtained from a background location. RST 3 also utilized laboratory analyses to ascertain the concentration of radon gas being emitted within living spaces of the one on-site building and verified the presence of residual contamination and potential releases of radiation-containing materials in soil and fill material associated with slag from the former Union Carbide facility.

Gamma radiological surveys were conducted using Fluke Pressurized Ionization Chamber (FPIC) Model 451P, Ludlum Model 2241 (Ludlum-2241), and Reuter-Stokes RSS-131ER High Pressure Ion Chamber (HPIC) gamma survey meters. Specific isotopes were identified using a Berkeley Nucleonics Corporation (BNC) SAM 940™ (SAM 940) portable, radioisotope identification system. The gamma survey instruments were used to identify on-site locations with above-background gamma readings and to determine on-site locations least likely impacted by historic on-site activities in order to select a location to obtain background readings. The background reading of each instrument was compared with survey data collected with each instrument to determine areas with elevated gamma readings. A Durridge RAD7 electronic radon/thoron detector was utilized to measure the concentration of radon and thoron in air. The background readings of each instrument utilized for the radiological survey indicated gamma at 9,900 to 10,700 cpm with Ludlum-2241, 7 to 16 µR/hr at waist-high and 9 to 17 µR/hr at contact with the FPIC, and 9.52 µR/hr with the HPIC. Background radon/thoron concentrations ranged from 0 to <4.0 pCi/L and no radionuclides were detected with the SAM-940.

Based upon the results from gross gamma survey conducted with Ludlum-2241 in the on-site building, gamma radiation exposure rates ranged from 6,500 cpm (below-background lower limit value) within the office to 16,100 cpm (less than 2x above the upper limit background value) within the viewing room. In most areas of the building, lower limit gamma exposure rates were generally below background values; however, upper limit gamma values were generally above the background upper limit value. There were no areas within the on-site building that exhibited gamma radiation exposure rates that were up to 2x above the background upper limit value. Based upon the results from outdoor gross gamma survey conducted with Ludlum-2241 throughout the Site, gamma radiation exposure rates ranged from 8,900 cpm (below background values) to 569,000 cpm (more than 53x above the background upper limit value). Outdoor gamma values were generally greater than the upper limit background value. Based upon the results from gamma survey conducted with the FPIC in the on-site building, waist-high and at-contact measurements, respectively, ranged from 3 to 19 µR/hr. FPIC gamma values were generally within the background upper limit value.

Based upon the results from gamma survey conducted with HPIC at three locations in the on-site building, gamma radiation exposure rates ranged from 9.56 to 10.94 µR/hr. Based upon the results from outdoor gamma survey conducted with HPIC at all the on-site soil sampling locations, gamma radiation exposure rates ranged from 10.02 µR/hr at soil sample location H001-SS005 to 256.34 µR/hr (more than 26x above-background value) at soil sample location

QAPP Worksheet #10: Problem Definition (Continued)

H002-SS008. Outdoor gamma values were generally greater than the background value. Based upon the results from gamma survey conducted with SAM-940 at a location on the east side of the on-site dirt road, radium-226 was detected.

Based upon the results from radon/thoron survey conducted with RAD7s in the on-site building, above-background concentrations of radon and thoron were not observed. Based upon the results from radon/thoron surveys conducted with RAD7s at all the eight on-site soil sampling locations, above-background concentration of radon was observed in at-contact measurement collected from soil sampling location H001-SS008. Waist-level thoron measurements collected from the eight soil sampling locations indicated above-background concentrations of thoron in five of the soil sampling locations (H001-SS003, H001-SS004, H001-SS005, H001-SS007, and H001-SS008) and at-contact measurements of thoron in two (H001-SS003 and H001-SS008) of the these five locations were above-background.

On August 10 through 13, 2015, an RST 3-procured National Radon Proficiency Program (NRPP)-certified company utilized passive activated charcoal canisters (radon canisters) to conduct short-term radon sampling tests that lasted a minimum of approximately 72 hours. A total of 15 radon canisters, including two field duplicates and one field blank, were deployed in the one on-site building. Canister placement was conducted in accordance with the guidelines set forth in the American National Standards Institute (ANSI)/American Association of Radon Scientists and Technologists (AARST) *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings* (MAMF 2012) and as directed by the EPA OSC. Radon testing locations were focused on frequently occupied spaces in the on-site building. Analytical results were compared with the EPA Site-Specific Action Level (SSAL) of 4.0 pCi/L. Analytical results did not indicate radon concentration above the EPA SSAL in any living spaces sampled within the on-site building.

On August 12, 2015, RST 3 conducted a soil sampling event to verify the presence of residual radiation-containing material in soil. Based upon the radiological survey data from SAT's prior site investigation and survey data from the radiological investigation conducted by RST 3 during this event, soil sampling locations suspected to contain radionuclides and metals/metalloids were identified and flagged on-site by the EPA OSC. RST 3 collected a total of nine soil samples including one field duplicate, from eight location on-site and one aqueous rinsate blank sample. The soil samples were analyzed for TAL metals (including mercury) via SW846, 6010C/7471B methods; isotopic thorium and isotopic uranium via alpha spectroscopy HASL-300-A-01-R; radium-226 (21 days ingrowth), radium-228 and other gamma emitting radioisotopes via gamma spectroscopy HASL-300-GA-01-R. The aqueous rinsate blank sample which was collected to demonstrate proper decontamination of non-dedicated sampling equipment i.e., Geoprobe cutting shoe, was analyzed for TAL metals, via EPA SW846 Method 6010C; total mercury, via EPA SW846 Method 7471B; isotopic thorium and isotopic uranium, via alpha spectroscopy HASL-300 Method A-01-R; other gamma emitting radioisotopes, via gamma spectroscopy Method GA-01-R; Radium-226, via EPA SW-846 Method 9315, and Radium-228 via EPA SW-846 Method 9320. Analytical results indicated elevated above-background concentrations of Ra-226 in three of the nine soil samples collected during this event. The concentration of cobalt was above the

QAPP Worksheet #10: Problem Definition (Continued)

EPA Removal Management Level (RML) of 70 mg/kg in one soil sample with a concentration of 110 mg/kg. Thallium concentration was above the EPA RML of 2.3 mg/kg in one soil sample with a concentration of 2.4 mg/kg.

On August 12, 2015, EPA collected four wipe samples, including one field blank, from access doorways in the on-site building. The wipe samples were collected in order to determine if radiation-containing materials were being tracked into the building by human traffic. The wipe samples were analyzed by EPA's health physicist using Ludlum-3030. Based upon the analytical results of the wipe samples for the selected counting durations, the minimum detectable concentration (MDC) for 100 square centimeter (cm^2) was determined as 0.80 disintegrations per minute (dpm) for alpha and 29.5 dpm for beta. These levels are below the 100 dpm and 1,000 dpm, respectively, for alpha and beta counts, outlined in the New York City Department of Health and Mental Hygiene (NYC DOHMH) Article 175 of the NYC Health Code, "Radiation Control", §175.03 - Release of Materials or Facilities, which was adopted by EPA as the SSAL for alpha and beta counts. Alpha and beta counts for all wipe samples were at the natural background level conservatively estimated by counting a blank wipe.

PROJECT DESCRIPTION

RST 3 will provide support to EPA for a gamma survey using a Ludlum-2241, Fluke PIC Model 451P, Reuter-Stokes RSS-131ER HPIC survey meters and BNC SAM 940 portable radioisotope identification system. RST 3 will subcontract the services of a NRPP-certified company, Accu-View Property Inspections, Inc. (AVPI), to provide field support in identifying radon canister placement in up to 15 locations, placing the canisters, picking up the canisters, and delivering to a private laboratory, Radon Testing Corporation of America (RTCA), for radon analysis.

OBSERVATION FROM ANY SITE RECONNAISSANCE REPORT

On August 10 through 13, 2015, an RST 3-procured NRPP-certified company utilized radon canisters to conduct short-term radon sampling tests that lasted a minimum of approximately 72 hours. A total of 15 radon canisters, including two field duplicates and one field blank, were deployed in the one on-site building. Canister placement was conducted in accordance with the guidelines set forth in the American National Standards Institute (ANSI)/American Association of Radon Scientists and Technologists (AARST) *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings* (MAMF 2012) and as directed by the EPA OSC. Radon testing locations were focused on frequently occupied spaces in the on-site building. Analytical results were compared with the EPA Site-Specific Action Level (SSAL) of 4.0 pCi/L. Analytical results did not indicate radon concentration above the EPA SSAL in any living spaces sampled within the on-site building.

QAPP Worksheet #10: Problem Definition (Concluded)

PROJECT DECISION STATEMENTS

EPA will use the field measurements from the radiological surveys to determine if radiation-containing materials are present on the residential property adjacent to the Site. In addition, the analytical results from the radon sampling event will enable EPA to determine the presence or absence of radon gas in living spaces of the residential property building. The combined results of the radiological survey and analytical data from this investigation will also be used to assist the EPA in determining whether a Removal Action is warranted at the Site.

QAPP Worksheet # 11:
Project Quality Objectives/Systematic Planning Process Statement

Overall project objectives include: To determine the presence or absence of radon in living spaces of a residential property building adjacent to the Site. An RST 3-procurred NRPP-certified company, AVPI will provide field support in placing the radon canisters at up to 15 locations, picking up the canisters, and delivering to RTCA for radon analysis. In addition, to determine if radiation-containing materials are present on the residential property through radiological surveys using a Ludlum-2241, Fluke PIC Model 451P, Reuter-Stokes RSS-131ER HPIC survey meters, and BNC SAM 940 portable radioisotope identification system.

Who will use the data? Data will be used by EPA, Region II On-Scene Coordinator (OSC).

What will the data be used for? The analytical data from this investigation will be used to assist the EPA in determining whether a Removal Action is warranted at the Site.

What types of data are needed?
Type of Data: Quantitative data for air measurements.

Analytical Techniques: Field survey equipment for air/Off-site laboratory analyses for air.

Parameters: Radon (Radon-222) for air matrix.

Type of survey/sampling equipment: Ludlum-2241, Fluke PIC Model 451P, Reuter-Stokes RSS-131ER HPIC, and BNC SAM 940 for gamma surveys, and activated charcoal canisters for radon samples.

Access Agreement: To be provided by EPA, Region II OSC.

Sampling locations: Radiological surveys will be conducted throughout the residential property located adjacent to the Site and radon sampling will be conducted inside the building of the residential property at locations that will be determined by the EPA OSC.

How much data are needed? Up to 15 radon samples, including field duplicates and field blanks, will be collected for air during the sampling event.

How "good" does the data need to be in order to support the environmental decision?
Sampling/analytical measurement performance criteria for Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameters will be established. Refer to Worksheet #12, criteria for performance measurement for definitive data.

Where, when, and how should the data be collected/generated? For radon sampling, the sampling locations will be determined on-site by the EPA OSC. Canisters will be placed inside on-site buildings about 20 inches above the ground and will collect ambient air for approximately 72 hours. The sampling event is scheduled to begin on April 17, 2016 and last approximately two weeks.

QAPP Worksheet # 11: Project Quality Objectives/Systematic Planning Process Statement (Concluded)

Who will collect and generate the data? The radon samples will be collected by personnel from AVPI and will be analyzed by RTCA laboratory. Radon analytical data will be reviewed and validated by RST 3 data validation personnel.

How will the data be reported? All data will be reported by the assigned laboratory (Preliminary, Electronic, and Hard Copy format). The Site Project Manager will provide a Sampling Trip Report, Status Reports, Maps/Figures, Analytical Report, and Data Validation Report to the EPA OSC.

How will the data be archived? Electronic data deliverables will be archived in a Scribe database. Non-CLP data will be archived in EPA's document control room.

QAPP Worksheet #12: Measurement Performance Criteria Table

(UFP-QAPP Manual Section 2.6.2)
Complete this worksheet for each matrix, analytical group, and concentration level. Identify the data quality indicators (DQI), measurement performance criteria (MPC) and QC sample and/or activity used to assess the measurement performance for both the sampling and analytical measurement systems. Use additional worksheets if necessary. If MPC for specific DQI vary within an analytical parameter, i.e., MPC are analyte-specific, then provide analyte-specific MPC on an additional worksheet.

Matrix	Air
Analytical Group	Radon
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
ANSI/AARST MAMF 2012	EPA Method 402-R-92-014	Precision	Relative Percent Difference (RPD) of +28% warning level and 30% control limit for duplicates of 4.0 pCi/L or greater. For duplicates of less than 4.0 pCi/L, the RPD warning level is 50% and the control limit is 67%.	Laboratory Duplicates	A
		Precision	RPD – 28%	Field Duplicates	A
		Accuracy	No analyte > DL	Field Blank Verification	A
		Accuracy	± 25% of the total value.	Data Completeness	A

QAPP Worksheet #13: Secondary Data Criteria and Limitations Table

Any data needed for project implementation or decision making that are obtained from non-direct measurement sources such as computer databases, background information, technologies and methods, environmental indicator data, publications, photographs, topographical maps, literature files and historical data bases will be compared to the DQOs for the project to determine the acceptability of the data. Thus, for example, analytical data from historical surveys will be evaluated to determine whether they satisfy the validation criteria for the project and to determine whether sufficient data was provided to allow an appropriate validation to be done. If not, then a decision to conduct additional sampling for the site may be necessary.

Secondary Data	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)	How Data May Be Used (if deemed usable during data assessment stage)	Limitations on Data Use
EPA Investigation	Site Inspection Report. DCN#: 2223-2A-BKYP	Weston Solutions, Inc. (SAT Region 2)	To determine possible areas of observed contamination.	Screening-level data
EPA Removal Assessments, August 2015	RST 3 Removal Assessment Trip Report, DCN#: RST3-02-D-0253	Weston Solutions, Inc. (RST 3 Region 2)	To verify the presence of residual radiological contamination in soil, identify potential releases of radiation-containing materials in soil and fill material, determine additional radiation source areas, and delineate the extent of on-site radiological contamination	Definitive data

QAPP Worksheet #14: Summary of Project Tasks

Survey Task:

Gamma Survey: RST 3 will delineate the area of observed contamination by measuring the gamma radiation exposure rates within the source area and at background locations. In accordance with Hazard Ranking System (HRS) requirements for naturally-occurring radionuclides, areas of observed contamination are defined by site-attributable radionuclide concentrations that equal or exceed a value two standard deviations above the mean site-specific background concentration or by gamma radiation exposure rates, measured by a survey instrument.

The presence/absence of gamma radiation will be determined by RST 3 using a Ludlum-2241 and a Fluke PIC Model 451P to obtain field survey data. A Ludlum-2241 with a sodium iodide gamma scintillator attached to it will be used to perform gross gamma survey. The sodium iodide scintillator will be held approximately 6 inches above the ground when collecting measurements. A mobile survey which will require the user to walk the Site along pre-determined paths will be performed. The highest and lowest readings from the Ludlum will be recorded for approximately 60 seconds in cpm. Using the PIC, two instantaneous measurements will be recorded at each location surveyed; one at contact (1 inch above the ground) and one at waist height (1 meter/3 feet above the ground). Survey time for each reading will be at least 30 seconds depending on the settling of the value. Data collected strategy with the PIC will be determined on-site by the OSC and may include, but not limited to using predetermined grids. All the results obtained from the PIC measurements will be recorded as a range (*e.g.* 4-6 μR/hr). If very low level gamma levels are observed, a Reuter Stokes RSS-131ER HPIC will be utilized to determine the exact levels. Specific radioisotopes will be identified using a BNC SAM 940 portable radioisotope identification system.

Sampling Task:

Radon-222 Sampling: In order to ascertain the concentration of Radon-222 in the residential building located adjacent to the Site, RST 3 will utilize the services of AVPI for the placement of up to 15 Activated Charcoal Canisters in living spaces of the building in accordance with the guidelines set forth in the ANSI/AARST *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings* (MAMF 2012) and as directed by EPA. Canisters will be raised above the ground approximately 20 inches, away from drafts or vents. The canisters will collect ambient air for a minimum of approximately 72 hours at each location. For each sampling event, weather information including, temperature, humidity, wind speed, and wind direction will be recorded. The radon canister samples will be analyzed for radon gas by RTCA via EPA Method 402-R-92-014.

Analysis Tasks:

Radon will be analyzed via activated charcoal canisters (ANSI/AARST MAMF 2012), EPA Method 402-R-92-014.

QAPP Worksheet #14: Summary of Project Tasks (Continued)

Quality Control Tasks:

Air matrices will have QC samples collected (i.e. field duplicates). All analytical methods will perform: Initial calibration, 10% laboratory duplicates; 59% field blank, monthly spike recovery, and all other applicable QC defined in the method.

Data Management Tasks:

Activities under this project will be reported in status and trip reports and other deliverables (e.g., analytical reports, final reports) described herein. Activities will also be summarized in appropriate format for inclusion in monthly and annual reports.

The following deliverables will be provided under this project:

Trip Report: A trip report will be prepared to provide a detailed accounting of what occurred during each sampling mobilization. The trip report will be prepared within two weeks of the last day of each sampling mobilization. Information will be provided on time of major events, dates, and personnel on-site (including affiliations).

Maps/Figures: Maps depicting site layout, contaminant source areas, and sample locations will be included in the trip report, as appropriate.

Analytical Report: An analytical report will be prepared for samples analyzed under this plan. Information regarding the analytical methods or procedures employed, sample results, QA/QC results, chain-of-custody documentation, laboratory correspondence, and raw data will be provided within this deliverable.

Data Review: A review of the data generated under this plan will be undertaken. The assessment of data acceptability or usability will be provided separately, or as part of the analytical report.

Documentation and Records:

All sample documents will be completed legibly, in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialing the error.

Field Logbook: The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. Field logbook will be bound and paginated. All entries will be dated and signed by the individuals making the entries, and should include (at a minimum) the following

1. Site name and project number
2. Name(s) of personnel on-site
3. Dates and times of all entries (military time preferred)
4. Descriptions of all site activities, site entry and exit times

QAPP Worksheet #14: Summary of Project Tasks (Continued)

5. Noteworthy events and discussions
6. Weather conditions
7. Site observations
8. Sample and sample location identification and description*
9. Subcontractor information and names of on-site personnel
10. Date and time of sample collections, along with chain of custody information
11. Record of photographs
12. Site sketches

* The description of the sample location will be noted in such a manner as to allow the reader to reproduce the location in the field at a later date.

Sample Labels: Sample labels will clearly identify the particular sample, and should include the following:

1. Site/project number.
2. Sample identification number.
3. Sample collection date and time.
4. Designation of sample (grab or composite).
5. Sample preservation.
6. Analytical parameters.
7. Name of sampler.

Sample labels will be written in indelible ink and securely affixed to the sample container. Tie-on labels can be used if properly secured.

Custody Seals: Custody seals demonstrate that a sample container has not been tampered with or opened. The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the sample packaging, will be noted in the field logbook.

Assessment/Audit Tasks: No performance audit of field operations is anticipated at this time. If conducted, performance and system audit will be in accordance with the project plan.

Data Review Tasks: All data will be validated by RST 3 (RST 3-procured laboratory data). Laboratory analytical results will be assessed by the data reviewer for compliance with required precision, accuracy, completeness, representativeness, and sensitivity.

QAPP Worksheet #15A: Reference Limits and Evaluation Table

Matrix: Air
Analytical Group: Radon
Concentration Level: Low

Analyte	Project Action Limit (pCi/L)	Project QL (pCi/L)	Laboratory Achievable DL
Radon	4.0	--	0.5 pCi/L

QAPP Worksheet #16: Project Schedule/Timeline Table

Activities	Organization	Dates (MM/DD/YY) Anticipated Date(s) of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Preparation of QAPP	RST 3 Contractor Site Project Manager	Prior to sampling date	4/13/2016	QAPP	4/15/2016
Review of QAPP	RST 3 Contractor QAO and/or Group Leader	Prior to sampling date	4/14/2016	Approved QAPP	4/15/2016
Preparation of Health and Safety Plan	RST 3 Contractor Site Project Manager	Prior to sampling date	4/14/2016	HASP	4/15/2016
Procurement of Field Equipment	RST 3 Contractor Site Project Manager and/or Equipment Officer	Prior to sampling date	4/14/2016	-	-
Laboratory Request	Not Applicable	Prior to sampling date	4/12/2016	CLP/Non-CLP Request Form	NA
Field Reconnaissance/Access	RST 3 Contractor Site Project Manager; or EPA Region II OSC	4/17/2016	4/29/2016	NA	NA
Collection of Field Samples	RST 3 Contractor Site Project Manager	4/22/2016	4/25/2016	NA	NA
Laboratory Electronic Data Received	RST 3 Contractor and EPA Region 2 DESA	5/5/2016	5/12/2016	Preliminary Data	5/12/2016
Laboratory Package Received	RST 3 Contractor and EPA Region 2 DESA	5/12/2016	5/19/2016	Validated Data	5/19/2016
Validation of Laboratory Results	RST 3 Contractor and EPA Region 2 DESA	5/19/2016	5/26/2016	Final Report	5/26/2016
Data Evaluation/ Preparation of Final Report	RST 3 Contractor Site Project Manager	5/26/2016	6/9/2016	Final Report	6/9/2016

QAPP Worksheet #17: Sampling Design and Rationale

Survey Task:

Gamma Survey: The presence/absence of gamma radiation will be determined by RST 3 using a Ludlum-2241 and a Fluke PIC Model 451P to obtain field survey data. A Ludlum-2241 with a sodium iodide gamma scintillator attached to it will be used to perform gross gamma survey. The sodium iodide scintillator will be held approximately 6 inches above the ground when collecting measurements. A mobile survey which will require the user to walk the Site along pre-determined paths will be performed. The highest and lowest readings from the Ludlum will be recorded for approximately 60 seconds in cpm. Using the PIC, two instantaneous measurements will be recorded at each location surveyed; one at contact (1 inch above the ground) and one at waist height (1 meter/3 feet above the ground). Survey time for each reading will be at least 30 seconds depending on the settling of the value. Data collected strategy with the PIC will be determined on-site by the OSC and may include, but not limited to using predetermined grids. All the results obtained from the PIC measurements will be recorded as a range (*e.g.* 4-6 µR/hr). If very low level gamma levels are observed, a Reuter Stokes RSS-131ER HPIC will be utilized to determine the exact levels. Specific radioisotopes will be identified using a BNC SAM 940 portable radioisotope identification system.

Sampling Task:

Radon-222 Sampling: In order to ascertain the concentration of Radon-222 in the residential building located adjacent to the Site, RST 3 will utilize the services of AVPI for the placement of up to 15 Activated Charcoal Canisters in living spaces of the building in accordance with the guidelines set forth in the ANSI/AARST *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings* (MAMF 2012) and as directed by EPA. Canisters will be raised above the ground approximately 20 inches, away from drafts or vents. The canisters will collect ambient air for a minimum of approximately 72 hours at each location. For each sampling event, weather information including, temperature, humidity, wind speed, and wind direction will be recorded. The radon canister samples will be analyzed for radon gas by RTCA via EPA Method 402-R-92-014.

The following laboratories will provide the analyses indicated:

Lab Name/Location	Sample Type	Parameters
Accu-View Property Inspections, Inc. PO Box 641 Buffalo, New York 14051	Air	Deploy and Retrieve Canisters for Radon Testing
Radon Testing Corporation of America 2 Hayes Street Elmsford, New York 10523	Air	Radon Testing

Refer to Worksheet #20 for QA/QC samples, sampling methods, and SOPs.

QAPP Worksheet #18: Sampling Locations and Methods/SOP Requirements Table

Matrix	Sampling Location(s)	Units	Analytical Group(s)	Concentration Level	No. of Samples (identify field duplicates)	Sampling SOP Reference	Rationale for Sampling Location
Air	15	pCi/L	Radon	Low	10% of total	SOP# 2001	Determine contaminants

The website for EPA-ERT SOPs is: http://www.ert.org/mainContent.asp?section=Products&subsection=List

QAPP Worksheet #19: Analytical SOP Requirements Table

Matrix	No. of Samples	Analytical Group	Concentration Level	Analytical / Preparation Method SOP Reference[1]	Containers (number, size, and type)	Sample volume[3] (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time[2] (preparation / analysis)
Air	15	Radon	Low	EPA Method 402-R-92-014 ANSI/AAST MAMF 2012	Activated Charcoal Canister	72 hour period of time	None	None

[1] Refer to the Analytical SOP References table (Worksheet #23).

[2] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

[3] The minimum sample size is based on analysis allowing for sufficient sample for reanalysis. Additional volume is needed for the laboratory Matrix Spike/Matrix Spike Duplicate sample analysis.

QAPP Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Sampling Locations	No. of Field Duplicate Pairs	No. of Extra Volume Laboratory QC (e.g., MS/MSD) Samples[1]	No. of Field Blanks[1]	No. of Trip. Blanks	No. of PE Samples
Air	Radon	Low	EPA Method 402-R-92-014 ANSI/AAST MAMF 2012	15	10% of total	NR	5% of total	5%	NR

MS/MSD not required for radon (air) samples.
NR – Not Required

QAPP Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP#2001	General Field Sampling Guidelines (all media); Rev. 0.0 August 1994	EPA/OSWER/ERT	Site Specific	N	--
ANSI/AARST MAMF 2012	*Protocol for Conducting Radon and Radon Decay Product Measurements In Multifamily Buildings,* 2012	U.S. EPA	Charcoal Canisters	N	**--**

See attachment B for SOP # 2001 and EPA 402-R-92-014
www.ert.org/mainContent.asp?section=Products&subsection=List

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

*Field Equipment
Trimble® GeoXT™ handheld, Ludlum-2241, Fluke Pressurized Ionization Chamber (PIC) Model 451P, Reuter-Stokes RSS-131ER High Pressure Ion Chamber (HPIC) gamma survey meters, and BNC SAM 940 radioisotope identification system.

* All on-site field equipment will be provided and operated by the EPA.

QAPP Worksheet #23: Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
ANSI/AARST MAMF 2012	Radon Analysis, via activated charcoal canisters	Definitive Data	Radon	Gamma ray Spectroscopy	RTCA – Elmsford, NY	N

QAPP Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for CA	SOP Reference[1]
Gamma ray Spectrometer	1. Analytical balance calibration 2. Analytical system performance check with radiation standard 3. Background radioactivity measurement with unexposed collectors	1. Daily 2. Monthly	• Gamma analyzer verified daily with certified Ra-226/ Ra-222 standard. • Any deviation above or below 2% from one day to next is investigated by laboratory.	• Recalibrate • Instrument maintenance • Consult with Technical Director	RTCA Laboratory / Analyst	RTCA SOP for Radon in Air-Charcoal Canisters

QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Gamma ray Spectrometer	As per Lab SOP	As per Lab SOP	As per Lab SOP	As per Lab SOP	As per Lab SOP	As per Lab SOP	RTCA Laboratory / Analyst	RTCA Lab SOP

[1] Specify the appropriate letter or number form the Analytical SOP References table (Worksheet #23)

QAPP Worksheet #26: Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): RST 3 Site Project Manager, Weston Solutions, Inc., Region II
Sample Packaging (Personnel/Organization): RST 3 Site Project Manager and sampling team members, Weston Solutions, Inc., Region II
Coordination of Shipment (Personnel/Organization): RST 3 Site Project Manager, sampling team members, Weston Solutions, Inc., Region II
Type of Shipment/Carrier: FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodian, RST 3-Procured Non-RAS Laboratory
Sample Custody and Storage (Personnel/Organization): Sample Custodian, RST 3-Procured Non-RAS Laboratory
Sample Preparation (Personnel/Organization): Sample Custodian, RST 3-Procured Non-RAS Laboratory
Sample Determinative Analysis (Personnel/Organization): Sample Custodian, RST 3-Procured Non-RAS Laboratory
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): Samples to be shipped same day of collection, and arrive at laboratory within 24 hours (1 day) of sample shipment
Sample Extract/Digestate Storage (No. of days from extraction/digestion): As per analytical methodology; see Worksheet #19
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodian, RST 3-Procured Non-RAS Laboratory
Number of Days from Analysis: Until analysis and QA/QC checks are completed; as per analytical methodology; see Worksheet #19.

QAPP Worksheet #27: Sample Custody Requirements

Sample Identification Procedures Each sample collected by Region II RST 3 will be identified by a property number (H001), a sample location number (001), the matrix identifier of the sample collected (AA for radon air sample) and the sample number (01). The last number will represent the sample number collected from each location. Duplicate samples will be identified in the same manner but will be the next sequential sample number (in most cases 02). e.g. H001-AA002-01; whereas, H001 = Property Number 001, AA001 = Radon Sample Location 002, 01 = Sample Number 01. Location of the sample collected will be recorded in the project database and site logbook. A duplicate sample will be identified in the same manner as other samples and will be distinguished and documented in the field logbook. Each sample will also be labeled with a non-CLP assigned number. Depending on the type of sample, additional information such as sampling round, date, etc. will be added.
Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Each sample will be individually identified and labeled after collection, then sealed with custody seals and enclosed in a plastic cooler. The sample information will be recorded on chain-of custody (COC) forms, and the samples shipped to the appropriate laboratory via overnight delivery service or courier. Chain-of-custody records must be prepared in Scribe to accompany samples from the time of collection and throughout the shipping process. Each individual in possession of the samples must sign and date the sample COC Record. The chain-of-custody record will be considered completed upon receipt at the laboratory. A traffic report and chain-of-custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples are not under direct control of the individual responsible for them, they must be stored in a locked container sealed with a custody seal. Specific information regarding custody of the samples projected to be collected on the weekend will be noted in the field logbook. The chain-of-custody record should include (at minimum) the following: 1) Sample identification number; 2) Sample information; 3) Sample location; 4) Sample date; 5) Sample Time; 6) Sample Type Matrix; 7) Sample Container Type; 8) Sample Analysis Requested; 9) Name(s) and signature(s) of sampler(s); and 10) Signature(s) of any individual(s) with custody of samples. A separate chain-of-custody form must accompany each cooler for each daily shipment. The chain-of-custody form must address all samples in that cooler, but not address samples in any other cooler. This practice maintains the chain-of-custody for all samples in case of mis-shipment.

QAPP Worksheet #27: Sample Custody Requirements (Concluded)

Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal): A sample custodian at the laboratory will accept custody of the shipped samples, and check them for discrepancies, proper preservation, integrity, etc. If noted, issues will be forwarded to the laboratory manager for corrective action. The sample custodian will relinquish custody to the appropriate department for analysis. At this time, no samples will be archived at the laboratory. Disposal of the samples will occur only after analyses and QA/QC checks are completed.

QAPP Worksheet #28: QC Samples Table
Radon

Matrix	Air
Analytical Group	Radon
Concentration Level	Low
Sampling SOP(s)	See QAPP Worksheet #18
Analytical Method/SOP Reference	ANSI/AARST MAMF 2012 / EPA Method 402-92-R-014
Sampler's Name	Richard F. Pezzino
Field Sampling Organization	Accu-View Property Inspections, Inc.
Analytical Organization	Radon Testing Corporation of America
No. of Sample Locations	15

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Lab Duplicate	10% of the sample	EPA Method 402-R-92-014	Identify problem and correct	Laboratory technician	Precision	Relative Percent Difference (RPD) of +28% warning level and 30% control limit for duplicates of 4.0 pCi/L or greater. For duplicates of less than 4.0 pCi/L, the RPD warning level is 50% and the control limit is 67%.
Monthly Spike	6 per month	Laboratory SOP	Identify problem and correct	Laboratory technician	Precision	$\pm$25%

Laboratory should follow method required QC Criteria.

QAPP Worksheet #29: Project Documents and Records Table

Sample Collection Documents and Records	Analysis Documents and Records	Data Assessment Documents and Records	Data Assessment Documents and Records	Other
Field Notes Digital Photographs Chain-of-Custody (COC) Records Air Bills Copies of Pertinent e-mails. Field Instrument Records	Record of Field Instrument. Measurements and Radiological Readings. Radiological Dosimetry Records. Corrective Action Reports. Radiological Instrument Calibration Readings.	Copies of all Analytical Data Deliverables; hard copies of raw data are archived; The raw data files from the laboratory include Analytical Instrument Calibration Records, COC Records, and Sample Preparation and Analysis Files, Sample Receipt Records	Copies of all Analytical Data Deliverables; hard copies of raw data are archived; The raw data files from the laboratory include Analytical Instrument Calibration Records, COC Records, and Sample Preparation and Analysis Files, Sample Receipt Records	Staff Health and Safety Records; CLP Request Form and RST 3 Analytical Request Form

QAPP Worksheet #30: Analytical Services Table

Matrix	Analytical Group	Concentration Level	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)
Air	Radon	Low	EPA Method 402-R-92-014	28 Days	Accu-View Property Inspections, Inc. PO Box 641 Buffalo, NY 14051 716-882-2200	NA
					Radon Testing Corporation of America 2 Hayes Street Elmsford, New York 10523 914-345-3380	

NA – Not Applicable

QAPP Worksheet #31: Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions (Title and Organizational Affiliation)
Laboratory Technical Systems/ Performance Audits	Every year	External	Regulatory Agency	Regulatory Agency	RST 3-Procured Laboratory	RST 3-Procured Laboratory	EPA, State, NRC, or other Regulatory Agency
Performance Evaluation Samples	Every year	External	Regulatory Agency	Regulatory Agency	RST 3-Procured Laboratory	RST 3-Procured Laboratory	EPA, State, NRC, or other Regulatory Agency
Proficiency Testing	Semiannually	External	NELAC	PT provider	Lab Personnel	Lab Personnel	Lab QA Officer
NELAC	Every two years	External	NELAC	NELAC Representative	Lab QA Officer	Lab Personnel	NELAC Representative
Internal Audit	Annually	Internally	TestAmerica Laboratories, Inc.	Lab QA Officer	Lab Personnel	Lab Personnel	Lab QA Officer

NRC: Nuclear Regulatory Commission

QAPP Worksheet #32: Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Project Readiness Review	Checklist or logbook entry	RST 3 Site Project Manager, Weston Solutions, Inc.	Immediately to within 24 hours of review	Checklist or logbook entry	RST 3 Site Project Leader	Immediately to within 24 hours of review
Field Observations/ Deviations from Work Plan	Logbook	RST 3 Site Project Manager, Weston Solutions, Inc. and EPA OSC	Immediately to within 24 hours of deviation	Logbook	RST 3 Site Project Manager and EPA OSC	Immediately to within 24 hours of deviation
Laboratory Technical Systems/ Performance Audits	Written Report	RST 3-Procured Laboratory	30 days	Letter	RST 3-Procured Laboratory	14 days
On-Site Field Inspection	Written Report	QAO/HSO Weston Solutions, Inc.	7 calendar days after completion of the audit	Letter/Internal Memorandum	Weston's regional QAO and/or EPA OSC	To be identified in the cover letter of the report

QAPP Worksheet #33: QA Management Reports Table

Type of Report	Frequency (Daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
RST 3-Procured Laboratory Data (preliminary)	As performed	Two weeks from the sampling date	RST 3-Procured Laboratory	RST 3 Data Validator and RST 3 Site Project Manager
RST 3-Procured Laboratory Data (validated)	As performed	Up to 14 days after receipt of preliminary data	RST 3 Data Validators	RST 3 Site Project Manager and OSC, EPA Region II
On-Site Field Inspection	As performed	7 calendar days after completion of the inspection	RST 3 Site Safety Officer	RST 3 Site Project Manager
Field Change Request	As required per field change	Three days after identification of need for field change	RST 3 Site Project Manager	EPA, Region II OSC
Final Report	As performed	2 weeks after receipt of EPA approval of data package	RST 3 Site Project Manager	EPA, Region II OSC

QAPP Worksheet #34: Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Site/field logbooks	Field notes will be prepared daily by the RST 3 Site Project Manager and will be complete, appropriate, legible and pertinent. Upon completion of field work, logbooks will be placed in the project files.	I	RST 3 Site Project Manager
Chains of custody	COC forms will be reviewed against the samples packed in the specific cooler prior to shipment. The reviewer will initial the form. An original COC will be sent with the samples to the laboratory, while copies are retained for (1) the Sampling Trip Report and (2) the project files.	I	RST 3 Site Project Manager
Sampling Trip Reports	STRs will be prepared for each week of field sampling [for which samples are sent to an EPA CLP RAS laboratory]. Information in the STR will be reviewed against the COC forms, and potential discrepancies will be discussed with field personnel to verify locations, dates, etc.	I	RST 3 Site Project Manager
Laboratory analytical data package	Data packages will be reviewed/verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	E	RST 3-Procured Laboratory
Laboratory analytical data package	Data packages will be reviewed as to content and sample information upon receipt by EPA.	I	RST 3 Site Project Manager
Final Sample Report	The project data results will be compiled in a sample report for the project. Entries will be reviewed/verified against hardcopy information.	I	RST 3 Site Project Manager

QAPP Worksheet #35: Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIa	SOPs	Ensure that the sampling methods/procedures outlined in QAPP were followed, and that any deviations were noted/approved.	RST 3 Site Project Manager
IIb	SOPs	Determine potential impacts from noted/approved deviations, in regard to PQOs.	RST 3 Site Project Manager
IIa	Chains of custody	Examine COC forms against QAPP and laboratory contract requirements (e.g., analytical methods, sample identification, etc.).	RST 3- procured laboratory - RST 3 data validator
IIa	Laboratory data package	Examine packages against QAPP and laboratory contract requirements, and against COC forms (e.g., holding times, sample handling, analytical methods, sample identification, data qualifiers, QC samples, etc.).	RST 3- procured laboratory - RST 3 data validator
IIb	Laboratory data package	Determine potential impacts from noted/approved deviations, in regard to PQOs. Examples include PQLs and QC sample limits (precision/accuracy).	RST 3- procured laboratory - RST 3 data validator
IIb	Field duplicates	Compare results of field duplicate (or replicate) analyses with RPD criteria	RST 3- procured laboratory - RST 3 data validator

QAPP Worksheet #36
Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa / IIb	Air	Radon	Sampling Method, Lab SOP, Calculations, QC Criteria	RST 3 Data Validation Personnel

QAPP Worksheet #37: Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: Data, whether generated in the field or by the laboratory, are tabulated and reviewed for Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCCS) by the SPM for field data or the data validator for laboratory data. The review of the PARCC Data Quality Indicators (DQI) will compare with the DQO detailed in the site-specific QAPP, the analytical methods used and impact of any qualitative and quantitative trends will be examined to determine if bias exists. A hard copy of field data is maintained in a designated field or site logbook. Laboratory data packages are validated, and final data reports are generated. All documents and logbooks are assigned unique and specific control numbers to allow tracking and management.
Questions about Non-CLP data, as observed during the data review process, are resolved by contacting the respective site personnel and laboratories as appropriate for resolution. All communications are documented in the data validation record with comments as to the resolution to the observed deficiencies.

Where applicable, the following documents will be followed to evaluate data for fitness in decision making: EPA QA/G-4, *Guidance on Systematic Planning using the Data Quality Objectives Process*, EPA/240/B-06/001, February 2006, and EPA QA/G-9R, *Guidance for Data Quality Assessment*, A reviewer's Guide EPA/240/B-06/002, February 2006.

Describe the evaluative procedures used to assess overall measurement error associated with the project:
As delineated in the ***Uniform Federal Policy for Implementing Environmental Quality Systems: Evaluating, Assessing and Documenting Environmental Data Collection and Use Programs Part 1: UFP-QAPP (EPA-505-B-04-900A, March 2005); Part 2A: UFP-QAPP Workbook (EPA-505-B-04-900C, March 2005); Part 2B: Quality Assurance/Quality Control Compendium: Non-Time Critical QA/QC Activities (EPA-505-B-04-900B, March 2005);*** "Graded Approach" will be implemented for data collection activities that are either exploratory or small in nature or where specific decisions cannot be identified, since this guidance indicates that the formal DQO process is not necessary.

The data will be evaluated to determine whether they satisfy the PQO for the project. The validation process determines if the data satisfy the QA criteria. After the data pass the data validation process, comparison results with the PQO is done.

QAPP Worksheet #37: Usability Assessment (Concluded)

EPA will use the field measurements from the radiological surveys to determine the presence or absence of radon/thoron gas and gamma radiation, the analytical results from the radon sampling event will be used to ascertain the concentration of Radon-222 in on-site buildings.

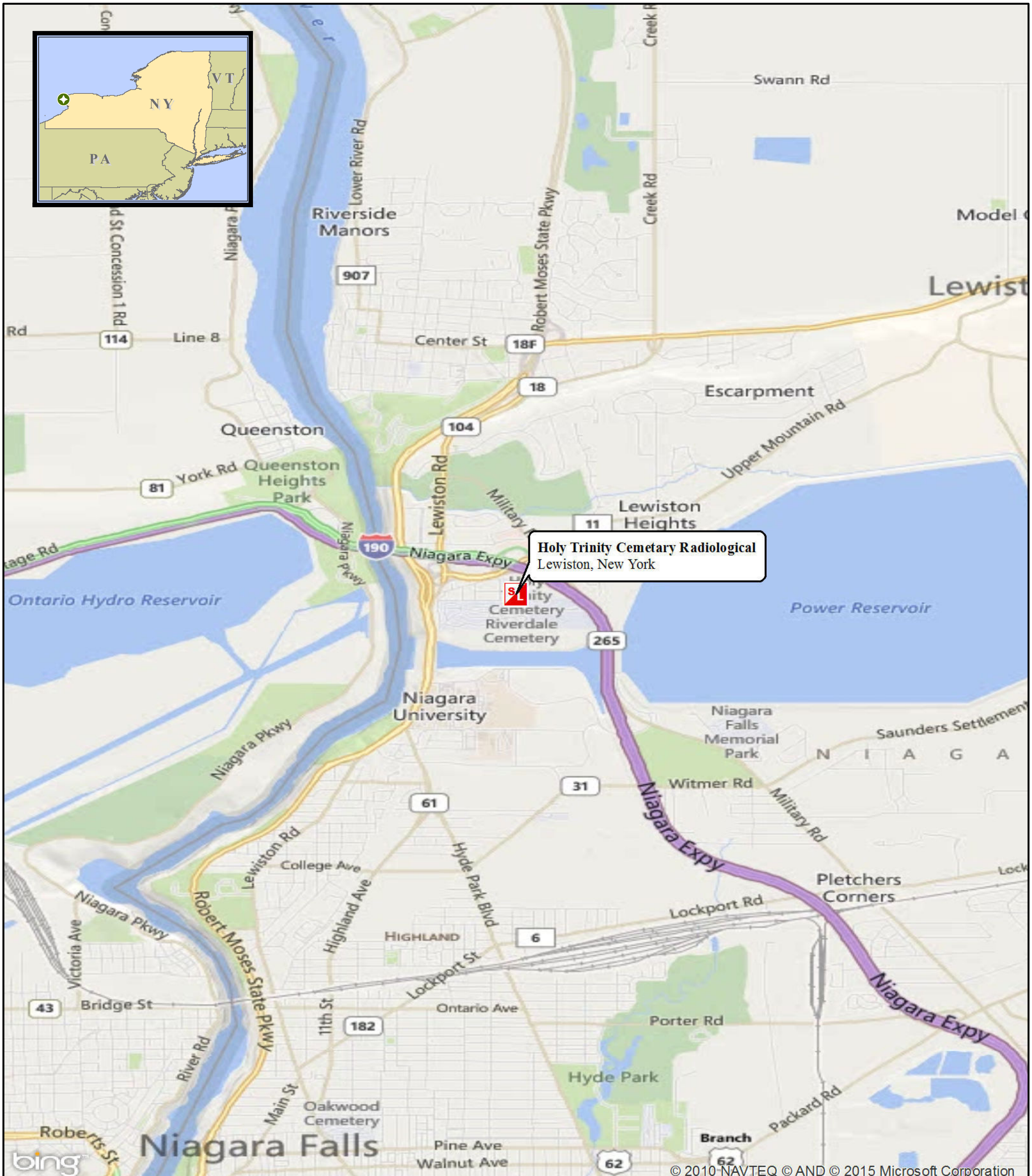
Identify the personnel responsible for performing the usability assessment: Site Project Manager, Data Validation Personnel, and EPA, Region II OSC

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

A copy of the most current approved QAPP, including any graphs, maps and text reports developed will be provided to all personnel identified on the distribution list.

ATTACHMENT A

Site Location Map



Legend

Site Location

N

0 0.3 0.6 1.2 1.8 2.4 Miles

Weston Solutions, Inc.
East Division

In Association With
Scientific and Environmental Associates, Inc.,
Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental,
Inc.and Sovereign Consulting, Inc

DATE MODIFIED: 7/30/2015

Figure 3:
Site Location Map

Holy Trinity Cemetery Radiological
Lewiston, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

GIS ANALYST:	T. Benton
EPA OSC:	E. Daly
RST SPM:	B. Nwosu
FILENAME:	140730_HT_SITELOCATIONMAP.MXD

C:\TEMP\00060064\MXD\140730_HT_SITELOCATIONMAP.MXD

ATTACHMENT B

Sampling SOP

EPA/ERT SOP # 2001 - General Field Sampling Guidelines

GENERAL FIELD SAMPLING GUIDELINES

SOP#: 2001
DATE: 08/11/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide general field sampling guidelines that will assist REAC personnel in choosing sampling strategies, location, and frequency for proper assessment of site characteristics. This SOP is applicable to all field activities that involve sampling.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Sampling is the selection of a representative portion of a larger population, universe, or body. Through examination of a sample, the characteristics of the larger body from which the sample was drawn can be inferred. In this manner, sampling can be a valuable tool for determining the presence, type, and extent of contamination by hazardous substances in the environment.

The primary objective of all sampling activities is to characterize a hazardous waste site accurately so that its impact on human health and the environment can be properly evaluated. It is only through sampling and analysis that site hazards can be measured and the job of cleanup and restoration can be accomplished effectively with minimal risk. The sampling itself must be conducted so that every sample collected retains its original physical form and chemical composition. In this way, sample integrity is insured, quality assurance standards are maintained, and the sample can accurately represent the larger body of material under investigation.

The extent to which valid inferences can be drawn from a sample depends on the degree to which the sampling effort conforms to the project's objectives. For example, as few as one sample may produce adequate, technically valid data to address the project's objectives. Meeting the project's objectives requires thorough planning of sampling activities, and implementation of the most appropriate sampling and analytical procedures. These issues will be discussed in this procedure.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected, and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest. Sample preservation, containers, handling, and storage for air and waste samples are discussed in the specific SOPs for air and waste sampling techniques.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The nature of the object or materials being sampled may be a potential problem to the sampler. If a material is homogeneous, it will generally have a uniform composition throughout. In this case, any sample increment can be considered representative of the material. On the other hand, heterogeneous samples present problems to the sampler because of changes in the material over distance, both laterally and vertically.

Samples of hazardous materials may pose a safety threat to both field and laboratory personnel. Proper health and safety precautions should be implemented when handling this type of sample.

Environmental conditions, weather conditions, or non-target chemicals may cause problems and/or interferences when performing sampling activities or when sampling for a specific parameter. Refer to the specific SOPs for sampling techniques.

5.0 EQUIPMENT/APPARATUS

The equipment/apparatus required to collect samples must be determined on a site specific basis. Due to the wide variety of sampling equipment available, refer to the specific SOPs for sampling techniques which include lists of the equipment/apparatus required for sampling.

6.0 REAGENTS

Reagents may be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

7.0 PROCEDURE

7.1 Types of Samples

In relation to the media to be sampled, two basic types of samples can be considered: the environmental sample and the hazardous sample.

Environmental samples are those collected from streams, ponds, lakes, wells, and are off-site samples that are not expected to be contaminated with hazardous materials. They usually do not require the special handling procedures typically used for concentrated wastes. However, in certain instances, environmental samples can contain elevated concentrations of pollutants and in such cases would have to be handled as hazardous samples.

Hazardous or concentrated samples are those collected from drums, tanks, lagoons, pits, waste piles, fresh spills, or areas previously identified as contaminated, and require special handling procedures because of their potential toxicity or hazard. These samples can be further subdivided based on their degree of hazard; however, care should be taken when handling and shipping any wastes believed to be concentrated regardless of the degree.

The importance of making the distinction between environmental and hazardous samples is two-fold:

(1) Personnel safety requirements: Any sample thought to contain enough hazardous materials to pose a safety threat should be designated as hazardous and handled in a manner which ensures the safety of both field and laboratory personnel.

(2) Transportation requirements: Hazardous samples must be packaged, labeled, and shipped according to the International Air Transport Association (IATA) Dangerous Goods Regulations or Department of Transportation (DOT) regulations and U.S. EPA guidelines.

7.2 Sample Collection Techniques

In general, two basic types of sample collection techniques are recognized, both of which can be used for either environmental or hazardous samples.

<u>Grab Samples</u>

A grab sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected all at once at one particular point in the sample medium. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

<u>Composite Samples</u>

Composites are nondiscrete samples composed of more than one specific aliquot collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can in certain instances be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask problems by diluting isolated concentrations of some hazardous compounds below detection limits.

Compositing is often used for environmental samples and may be used for hazardous samples under certain conditions. For example, compositing of hazardous waste is often performed after compatibility tests have been completed to determine an average value over a number of different locations (group of drums). This procedure generates data that can be useful by providing an average concentration within a number of units, can serve to keep analytical costs down, and can provide information useful to transporters and waste disposal operations.

For sampling situations involving hazardous wastes, grab sampling techniques are generally preferred because grab sampling minimizes the amount of time sampling personnel must be in contact with the wastes, reduces risks associated with compositing unknowns, and eliminates chemical changes that might occur due to compositing.

7.3 Types of Sampling Strategies

The number of samples that should be collected and analyzed depends on the objective of the investigation. There are three basic sampling strategies: random, systematic, and judgmental sampling.

Random sampling involves collection of samples in a nonsystematic fashion from the entire site or a specific portion of a site. Systematic sampling involves collection of samples based on a grid or a pattern which has been previously established. When judgmental sampling is performed, samples are collected only from the portion(s) of the site most likely to be contaminated. Often, a combination of these strategies is the best approach depending on the type of the suspected/known contamination, the uniformity and size of the site, the level/type of information desired, etc.

7.4 QA Work Plans (QAWP)

A QAWP is required when it becomes evident that a field investigation is necessary. It should be initiated in conjunction with, or immediately following, notification of the field investigation. This plan should be clear and concise and should detail the following basic components, with regard to sampling activities:

- Objective and purpose of the investigation.
- Basis upon which data will be evaluated.
- Information known about the site including location, type and size of the facility, and length of operations/abandonment.
- Type and volume of contaminated material, contaminants of concern (including concentration), and basis of the information/data.
- Technical approach including media/matrix to be sampled, sampling equipment to be used, sample equipment decontamination (if necessary), sampling design and rationale, and SOPs or description of the procedure to be implemented.
- Project management and reporting, schedule, project organization and responsibilities, manpower and cost projections, and required deliverables.
- QA objectives and protocols including tables summarizing field sampling and QA/QC analysis and objectives.

Note that this list of QAWP components is not all-inclusive and that additional elements may be added or altered depending on the specific requirements of the field investigation. It should also be recognized that although a detailed QAWP is quite important, it may be impractical in some instances. Emergency responses and accidental spills are prime examples of such instances where time might prohibit the development of site-specific QAWPs prior to field activities. In such cases, investigators would have to rely on general guidelines and personal judgment, and the sampling or response plans might simply be a strategy based on preliminary information and finalized on site. In any event, a plan of action should be developed, no matter how concise or informal, to aid investigators in maintaining a logical and consistent order to the implementation of their task.

7.5 Legal Implications

The data derived from sampling activities are often introduced as critical evidence during litigation of a hazardous waste site cleanup. Legal issues in which sampling data are important may include cleanup cost recovery, identification of pollution sources and responsible parties, and technical validation of remedial design methodologies. Because of the potential for involvement in legal actions, strict adherence to technical and administrative SOPs is essential during both the development and implementation of sampling activities.

Technically valid sampling begins with thorough planning and continues through the sample collection and analytical procedures. Administrative requirements involve thorough, accurate documentation of all sampling activities. Documentation requirements include maintenance of a chain of custody, as well as accurate records of field activities and analytical instructions. Failure to observe these procedures fully and consistently may result in data that are questionable, invalid and non-defensible in court, and the consequent loss of enforcement proceedings.

8.0 CALCULATIONS

Refer to the specific SOPs for any calculations which are associated with sampling techniques.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Refer to the specific SOPs for the type and frequency of QA/QC samples to be analyzed, the acceptance criteria for the QA/QC samples, and any other QA/QC activities which are associated with sampling techniques.

10.0 DATA VALIDATION

Refer to the specific SOPs for data validation activities that are associated with sampling techniques.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety procedures.

ATTACHMENT C

Protocol for Conduction Radon and Radon Decay
Product Measurements in Multifamily Buildings

Protocol for Conducting
Radon and Radon Decay Product Measurements
In Multifamily Buildings

For Residence Managers and Measurement Professionals

Designation: ANSI/AARST MAMF 2012

Replication with no change from ANSI/AARST MAMF 2010

An American National Standard

SCOPE:

This standard specifies procedures, minimum requirements and general guidance for measurement of radon and radon decay product concentrations in Multifamily buildings comprised of more than three attached dwellings.

THIS DOCUMENT INCLUDES:

1) **Introduction to Radon.**
2) **Introductory Guidance for Residence Managers.**
3) **Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings.**

   Specific testing protocols that include instructions on where to test, strategies for conducting reliable tests, reporting and associated quality control measures.

Significance of Use:

This document contains protocols and guidance designed to respond to the health threat of radon in dwellings in Multifamily buildings.

Radon has been determined to be the leading cause of lung cancer among nonsmokers in the United States. It is believed that most people receive their greatest exposure to radon in their home or dwelling. The U.S. EPA and the Surgeon General state that "Indoor radon is the second-leading cause of lung cancer [after cigarette smoking] in the United States and breathing it over prolonged periods can present a significant health risk to families all over the country." *(Health Advisory, January 13, 2005)*

The purpose of conducting radon measurements is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary in order to protect current or future occupants. The purpose of test protocols is to help achieve reliable radon measurements. This standard addresses the needs of citizens, radon measurement professionals, property owners, residence/facility managers, consultants, manufacturers and regulators concerned with radon measurements in Multifamily buildings.

Introduction

History: The United States Environmental Protection Agency (EPA) developed measurement guidelines in the *Home Buyer's and Seller's Guide to Radon* and the *Citizen's Guide to Radon*. For the current versions see: http://www.epa.gov/radon/pubs. These measurement strategies assess radon concentrations in homes for the purpose of determining the need for remedial action. Guidelines or protocols also appear in the EPA documents "Indoor Radon and Radon Decay Product Measurement Device Protocols" and "Protocols for Radon and Radon Decay Product Measurements in Homes. The protocols and guidance herein include the best practices from those documents, additional technical descriptions of requirements and recommendations, and guidelines for the interpretation of measurement results.

The Stewart McKinney Amendments to the 1988 Indoor Radon Abatement Act require U.S. Housing and Urban Development (HUD) to develop an effective departmental policy for dealing with radon contamination using available guidelines and standards to ensure that occupants of housing subsidized by HUD are not exposed to hazardous concentrations of radon. At the request of Congress, the document "Radon Measurement in HUD Multifamily Buildings" was developed to enable HUD to comply with the requirements of the legislation. The document was completed during 1995 by the EPA for HUD under interagency agreement. The American Association of Radon Scientists and Technologists document "AARST Interim Protocols for Conducting Radon Measurements in Multifamily Buildings (MAMF October, 2004)" built on that document and added consortium review and revision. The document herein reflects a significant degree of continued review and amendment.

Applicability and use of this document*:* If the minimum requirements of this document exceed local, state, or federal requirements for the locale in which the radon test is conducted, then this document's minimum requirements should be followed. This document is intended to aid multifamily building owners/managers and staff, residents, owners of individual dwellings, radon measurement professionals, state radiation control programs or anyone involved in the measurement of radon in Multifamily buildings to assess the need for mitigation and to provide radon risk information for the benefit of occupants. These guidelines can be adopted as part of a state program or can be provided as recommendations by states to testing companies and interested individuals. AARST recommends that any authority or jurisdiction that is considering substantial modifications of this document as a condition of its use seek consensus within the consortium process at AARST Consortium on National Radon Standards prior to adopting a modified version. This provides the jurisdiction with a higher degree of expertise and an opportunity for the Consortium on National Radon Standards to update its document if appropriate.

Keywords:

Radon Gas, Radon Test, Multifamily, Radon Measurement, Radon Testing, Radon, Multifamily Housing

Normative References:

- EPA Guidance on Quality Assurance (402-R-95-012, October 1997)
- Indoor Radon and Radon Decay Product Measurement Device Protocols (EPA 402-R-92-004, July 1992)

For the latest versions of USEPA documents see:
http://www.epa.gov/radon/pubs

Referenced Publications:

- A Citizen's Guide To Radon (EPA 402/K-09/001, January 2009)
- Home Buyers and Sellers Guide to Radon (EPA 402/K-09/-002, January 2009)

For the latest versions of USEPA documents see:
http://www.epa.gov/radon/pubs

- Protocols For Radon Measurements In Homes (AARST MAH September 2005)

For the latest versions of AARST documents see:
http://www.aarst.org

Metric Conversions

Conversions from English-American measurement units to the International System of Units (SI) are rendered herein with literal conversion. The conversions are not always provided in informational text or tables. It is acknowledged that rounding off to a similar numeric conversion is common (i.e. 4.0 pCi/L rounded to 150 Bq/m^3 rather than literal conversion to 148 Bq/m^3) for locations where the International System of Units (SI) are used in standard practice. Conversions should apply as commonly used in such locations or jurisdictions.

Consensus Process

The consortium consensus processes developed for the AARST Consortium on National Radon Standards and as accredited to meet essential requirements for American National Standards by the American National Standards Institute (ANSI) have been applied throughout the process of approving this document. This Standard is to be reviewed and updated every five years at a minimum.

Notice regarding unresolved objections: While each committee seeks to resolve objections, please notify the committee responsible for an action or inaction if you desire to re-circulate any unresolved objections to the committee for further consideration. **Notice of right to appeal.** (See Bylaws for the AARST Consortium on National Radon Standards - Operating Procedures for Appeals available at www.radonstandards.us, Standards Forum, Bylaws): (2.1) Persons or representatives who have materially affected interests and who have been or will be adversely affected by any substantive or procedural action or inaction by AARST Consortium on National Radon Standards committee(s), committee participant(s), or AARST have the right to appeal; (3.1) Appeals shall first be directed to the committee responsible for the action or inaction.

Contact information:
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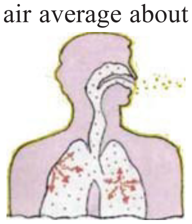
TABLE OF CONTENTS

Section I: Introduction to Radon

(This section is intended for informational purposes only. For radon testing protocol, see Section III).

A. Radon Facts

Radon is a naturally-occurring radioactive gas which is a part of the uranium-238 decay chain. The immediate parent of radon-222 is radium-226. Radon comes from the breakdown (radioactive decay) of uranium that is found in soil and rock all over the United States. Radon is a component of the air in soil that enters buildings through cracks and other pathways in the foundation. Eventually, it decays into radioactive particles (decay products) that can become trapped in your lungs when you inhale. As these particles decay in turn, they release small bursts of radiation. This radiation can damage lung tissue and lead to lung cancer over the course of your lifetime. EPA studies have found that radon concentrations in outdoor air average about 0.4 pCi/L (picocuries per liter) of air. However, radon and its decay products can reach much higher concentrations inside a building.



Radon gas is colorless, odorless, and tasteless. The only way to know whether elevated concentrations of radon are present in any building is to test.

B. Radon's Health Effects

Radon is a known human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks. EPA calculates that radon may cause 21,000 lung cancer deaths in the U.S. each year. The U.S. Surgeon General has warned that radon is the leading cause of lung cancer deaths in non-smokers in the U.S. Only smoking causes more lung cancer deaths than radon.

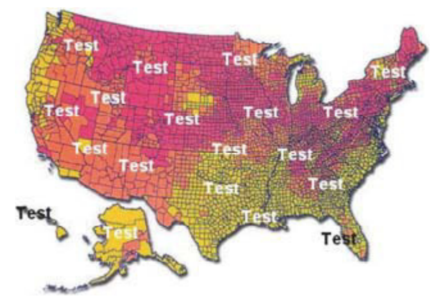
Not everyone who breathes radon decay products will develop lung cancer. An individual's risk of getting lung cancer from radon depends mostly on three factors: the concentration of radon, the duration of exposure and the individual's smoking habits. In addition, some people are more susceptible to lung cancer than others.

Risk increases as an individual is exposed to higher concentrations of radon over a longer period of time. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than it is for non-smokers.

C. Radon Exposure

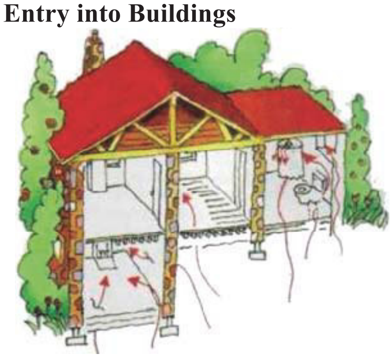
Because many people spend much of their time at home, the home is likely to be the most significant source of radon exposure. According to EPA, nearly 1 out of every 15 homes in the United States is estimated to have radon concentrations that exceed the EPA action level.

Elevated concentrations of radon have been found in homes and buildings in every state. While elevated radon may be more common in some areas, any building can have a problem. EPA recommends that ALL buildings should be tested regardless of the area of the country and that maps should not be used to determine whether to test. More specific information on the likelihood of elevated radon in your area can frequently be found at your state or county radon offices.



The concentration of radon in the air within a building should be reduced below **EPA's radon action level of 4 pCi/L.** Any radon exposure creates some risk; no concentration of radon is safe. Even radon concentrations below 4 pCi/L pose some risk, and the risk of lung cancer can be reduced by lowering indoor radon concentrations. This action level is based largely on the ability of current mitigation technologies to consistently reduce radon concentrations below 4 pCi/L. Depending on the building characteristics, radon concentrations in some buildings can be reduced well below 4 pCi/L. In others, reducing radon concentrations to below 4 pCi/L may be more difficult.

D. Radon Entry into Buildings



Radon in soil gas is the main source of radon problems. Pathways for radon to enter a building include cracks in the slabs and walls, the expansion joints between floor and walls, porous concrete block walls, open sump pits, crawlspaces and openings around utility penetrations. Some buildings have other pathways for radon to enter a building such as sub-slab utility tunnels and heating, ventilating and air conditioning (HVAC) ducts.

Radon gas may also enter buildings in well water. Radon from well water used in a building can off-gas and raise the concentrations. For dwellings or small communities serviced by well water, a test of the water for radon should be considered especially if the building is vacant or there is no water use during the test in the dwellings. Radon in water testing is covered in a separate document and is beyond the scope of this testing protocol. For more information on radon in drinking water you can contact your state radon contact, your state drinking water program, EPA's Drinking Water Hotline (800) 426-4791, or visit http://www.epa.gov/safewater/radon.html.

Sometimes building materials that contain uranium and radium can produce radon. A radiation professional or your state radiation program can help you evaluate this possibility.

Factors Influencing Radon Entry

Many factors contribute to the entry of radon gas into buildings. As a result, residence managers cannot know without testing if elevated concentrations of radon are present in their building complex. The following factors determine why some buildings have elevated radon concentrations and others do not:

- The concentration of radon in the soil gas **(source strength);**
- The permeability of the soil or sub-surface geology **(gas mobility)** under the building;
- The **structure and construction** of a building; and,
- The type, design, operation, and maintenance of the heating, ventilating and air-conditioning **(HVAC)** system.

Source strength: The radon concentration in soil gas can vary greatly from building to building. It can even vary greatly under different parts of the same building.

Gas mobility: Certain geological features beneath a building, such as cracks, fissures, or solution cavities, can serve as a direct connection between the radon-producing minerals and the building's foundation. Such a direct connection can cause one unit of a building to have a radon concentration significantly higher than other units in the area. The permeability of the soil under a building, along with the differences between the air pressure inside a building and the air pressure under a building's foundation influence the rate at which radon enters a building. For example, if the air pressure in the building is greater than the air pressure under the building's foundation, radon should not enter through the openings of a building's foundation. If the air pressure in the building is less than the air pressure under the building's foundation, radon in the soil gas will enter through any openings in the building's foundation.

Structure and construction: Any building design can have a radon problem. Without testing, you cannot know if elevated concentrations of radon are present.

Heating, cooling and ventilation systems (HVAC): Depending on their design and operation, HVAC systems can influence radon concentrations in buildings:

- Fresh air ventilation serves to dilute indoor radon concentrations with outdoor air; however radon's source strength commonly overwhelms the practical limits of increasing ventilation to reduce occupant exposure.
- Poor ventilation provides less dilution to indoor radon concentrations.
- Depressurized buildings draw radon inside.
- Pressurizing a building helps keep radon out.

The frequency and thoroughness of HVAC maintenance can sometimes play an important role. For example, air intake filters that are not periodically cleaned and changed can significantly reduce the amount of outdoor air ventilating the indoor air environment. An understanding of the design, operation, and maintenance of a building's HVAC system and how it influences indoor air conditions is helpful for understanding and managing a radon problem, as well as many other indoor air quality concerns in buildings. However, since HVAC systems are only one of many factors that affect radon concentrations in a building, HVAC system modifications alone are often not an effective radon mitigation strategy.

E. Contacts for Additional Information

- EPA Website
  http://www.epa.gov/radon
- State radon offices:
  http://www.epa.gov/iaq/whereyoulive.html
- Indian Nation radon offices:
  http://www.epa.gov/epahome/tribal.htm
- Regional EPA offices:
  http://www.epa.gov/epahome/locate2.htm
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: www.nrsb.org
- The NEHA (National Environmental Health Association) National Radon Proficiency Program: www.neha-nrpp.org

Informational Section

SECTION II: INTRODUCTORY GUIDANCE FOR RESIDENCE MANAGERS

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

***(For individuals testing a single dwelling, the following** subsections C, F, G, H and I provide helpful information.)*

A. Introduction

The purpose of testing is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary to protect current or future occupants.

Planning

Planning to test your building for radon requires a basic understanding of the radon testing process and the steps that are necessary to ensure your radon test results are reliable. Specifically, to plan for radon testing, you will need to:

- Become familiar with testing methods and building conditions required to conduct reliable radon tests;
- Determine an appropriate and practical testing strategy (see Section III). Review logistics and estimate the number of detectors including detectors for quality assurance (QA) requirements to aid in evaluating costs and competitive bids from companies providing radon testing services;
- Investigate whether any residents have independently tested their dwelling for radon and collect any test results;
- Communicate information to your residents about your radon testing activities;
- Become familiar with guidance for when radon reduction is recommended.

A responsible and reliable plan for radon measurement requires technical knowledge, attention to detail, and planning. **You should use a radon measurement professional that is state licensed or nationally certified by NEHA-NRPP or NRSB if no state licensing program exists in the state where the measurements are conducted.** (See C below for information on finding a qualified contractor for your area.) A radon measurement professional can help assess the nature of your building complex and help you choose a responsible and reliable measurement plan.

(See Appendix E for a step-by-step checklist on planning and testing.)

B. Communicating with Residents Prior to Testing

It is important to notify and inform residents prior to testing about what to expect during the testing process. Plan to:

- Distribute an appropriate ***notice of inspection (for radon testing)*** at least two weeks in advance of testing and again a few days before the test that provides the likely placement and retrieval dates and required building conditions prior to and during the test. The notice should stress the importance of providing access to test locations and maintaining proper test conditions. Include advice that interfering with the test device or building conditions can invalidate the test results. It should also stress that the test is being conducted to help ensure the occupants' safety. Inform residents how they might get more information. (See Exhibits 5 through 9 for sample notification forms.)
- Inform residents that test devices are not dangerous in any way and that a sample test device is available if residents wish to see the device.
- Inform residents when test results might be available and that copies of EPA's current *A Citizen's Guide to Radon,* current comparable EPA documents or state-approved radon documents are available upon request to residents who want additional information on radon. For copies of these guides, contact your State Radon Office or access http://www.epa.gov/radon/whereyoulive.html.

C. Selecting Radon Service Contractors

Your goal is to select a contactor who will provide reliable services and techniques. When seeking radon services, request bids from radon measurement professionals who are state licensed (where applicable) or certified by either the National Radon Proficiency Program (NEHA-NRPP) or the National Radon Safety Board (NRSB) and who use approved devices.

Contact your State Radon Office for a list of licensed or certified contractors (http://www.epa.gov/radon/whereyoulive.html).

Listings for certified contractors can also be found at www.neha-nrpp.org or www.nrsb.org. (For more information on private radon proficiency programs, visit www.epa.gov/radon/proficiency.html).

State regulations will take precedence when they are more stringent.

Individuals placing and retrieving detectors should have an identification card or letter verifying their participation in State, NEHA-NRPP or NRSB Radon Proficiency Programs. Devices used for the measurements should also be approved by NEHA-NRPP or NRSB Radon Proficiency Programs.

D. Role of Maintenance Personnel

Because maintenance personnel frequently have knowledge of the building and the occupants, they can play a key role during the testing process, especially in planning and scheduling. By providing access to residences and supplying floor plans when available, the maintenance personnel can help the measurement service to quickly identify appropriate testing locations, and plan testing strategy within a building complex.

It is highly recommended that untrained personnel serve only in these support functions for trained and certified or licensed radon measurement professionals. In regulated states, all parties including unlicensed and untrained personnel must abide by state regulations.

E. Documenting the Testing Program

A record of the testing program should be maintained by the client for future reference. This record should contain the following information:

- A copy of the final report submitted by the measurement service that conducted the tests and the measurement service's statement outlining any recommendations concerning retesting or mitigation. (Section III 8.0 describes appropriate documentation.)
- All correspondence between you and the measurement service.

F. When to Test

Short-term radon tests (tests lasting just a few days) require minimizing air exchange into and out of a building: closed-building conditions. For testing programs where the occupants may not be active participants in the testing process, actions must be considered to help ensure closed-building conditions for short term tests.

Choosing a time of year when required closed-building conditions are a normal condition will aid in ensuring reliable measurements.

Real-Estate Transactions: Testing for radon prior to every transfer of a residential dwelling to a new owner is recommended. Even if a building has been tested before, additional measurements help to ensure that conditions, including structure and ventilation, have not changed. (Note that disclosure regarding inspections and radon levels found are usually required during real-estate transactions. Your State Radon Office or other local authority may be able to provide additional information.) Property owners should also consider testing in advance of initiating a real estate sale so that the transaction will not later be delayed.

Non-Real-Estate Testing: Although radon testing can begin at any time during the year, consider conducting measurements during a time of year when required closed-building conditions are the normal conditions. For example: In cooler climates it is recommended that you schedule short-term testing during the colder months of the year (i.e. heating seasons such as October through March). Contact your State Radon Office for information on seasonal variations.

G. Retesting

Many factors can cause indoor radon concentrations in your building to change over time. New openings to the earth may develop due to settling/deterioration of the building structure and/or construction or renovation work including energy upgrades. Pressure relation*s*hips can change if HVAC equipment is added, removed, replaced, operated differently or improperly maintained. These changes may produce elevated radon concentrations in rooms in which the initial radon test results were below 4 pCi/L (148 Bq/m^3). Therefore, ***retesting*** the building every five years is recommended.

When tests indicate low concentrations, consider confirming low concentrations by repeating tests during different seasons and weather conditions to account for possible seasonal variations.

In addition, radon concentrations should be retested when the following occur:

- A new addition is added;
- Significant changes to the slab or foundation such as major cracks or penetrations that occur due to natural settling, water proofing or groundwater control efforts;
- Significant construction blasting or earthquakes occur nearby;
- An installed mitigation system is altered, modified or repaired;
- A ground contact area that was not previously tested is occupied.

<u>Retests after mitigation:</u> To provide an initial measure of radon reduction system effectiveness, conduct a short-term measurement no sooner than 24 hours after a radon reduction system is operational and within 30 days after installation of system. Conduct the test in the same location as the pre-mitigation test location or the lowest livable area. Also conduct a post-mitigation test in the lowest livable area above any crawlspace that is structurally isolated. It is recommended that additional measurements be conducted in the lowest livable area above each other unique structural area. Additional testing should be conducted in the areas that were mitigated at least every two years to ensure that the system remains effective, and testing may be conducted as often as desired.

Informational Section

H. Actions Recommended Based Upon Test Results

4 pCi/L (148 Bq/m^3) **or greater.**

If testing indicates radon concentrations equal to or greater than 4 pCi/L in any apartment, office area, exercise facility, meeting room, dining area or other common area, you should reduce the radon to below 4 pCi/L. The higher the radon concentration, the more quickly action should be taken to reduce the concentrations.

Below 4 pCi/L (148 Bq/m^3).

Radon concentrations below 4 pCi/L still pose some risk. If test results are below 4 pCi/L, confirm the low results by testing again, at least every five years and whenever significant changes to the building's structure or mechanical systems occur. (See G above for more information.)

You may also consider conducting a long-term test or several short-term tests in different seasons of the year. The closer a long-term measurement is to 365 days, the more representative it will be of annual average radon concentrations. Such considerations may be especially important in regions where geology or other factors may cause wide variations in radon concentrations.

Between 2 and 4 pCi/L (Between 74 and 148 Bq/m^3)

If the test results are between 2 and 4 pCi/L, you should consider taking measures to reduce the concentrations in the building. (Note that reducing and accurately confirming radon concentrations of about 2.0 pCi/L or below may be difficult.)

100 pCi/L (3,700 Bq/m^3) **or greater**

Call the State Radon Office or Department of Health for immediate protective action recommendations if radon test results approach 100 pCi/L or greater.

For Non-Residential Rooms/Enclosed Spaces:

Reduce the radon concentration

1. if testing indicates radon concentrations equal to or greater than 4 pCi/l in these locations

AND

2. if either (a) these areas are occupiable with little or no modification, or (b) these areas serve as a source of radon into apartments and offices of upper story floors that have radon concentrations equal to or greater than 4 pCi/l.

(See Section III for complete testing protocol.)

I. Mitigation

How quickly to begin the mitigation process will depend on the radon concentration detected. Elevated radon concentrations of more than twice the action level [or more than 8 pCi/L (296 Bq/m^3)] demand a quicker response.

How to Mitigate

To successfully lower radon concentrations, conditions in the entire building must be evaluated. Reducing radon concentrations requires diagnostics and mitigation.

- Diagnostics may include evaluation of radon entry points, air pressure relationships within and under a building and other factors. Diagnostics are often needed to identify the appropriate radon reduction technique and design.
- Mitigation is the design and implementation of a radon reduction system.

You should use a contractor who is trained and licensed or certified to fix radon problems. A qualified contractor can investigate a radon problem in your building and help you choose the right treatment method. Lowering high radon concentrations requires technical knowledge and special skills.

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Protocol

Section III:

Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings

1.0 Purpose and Scope

1.1 Purpose: The purpose of conducting radon measurements is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary in order to protect current or future occupants. The purpose of test protocols is to help achieve reliable radon measurements.

1.2 Scope: These protocols address measuring radon concentrations in Multifamily buildings comprised of more than three attached dwellings. When testing single-family residences or buildings comprised of three or fewer attached dwellings, see applicable EPA or state-specific standards or protocols.

These protocols may be employed for testing structures whether conducted for non-real estate purposes or when associated with a real estate transaction. Tests conducted for an individual dwelling in a multifamily building including condominiums or co-op units may employ these strategies yet conditions that meet the requirements of 6.0 below (Conditions required before and during the test) are still required for the whole building when short-term detectors are deployed.

1.3 Limitations: Suggested best practices to help ensure testing quality have been included, however:

1.3.1 This document is not intended to address all detailed technical aspects of measurement device technology or quality assurance.

1.3.2 Radon Decay Products: Due to difficulties establishing appropriate controlled conditions and other related concerns, the consensus of stakeholders found that radon decay product measurements require additional steps to create the conditions in residences that would allow them to be used to make radon mitigation decisions. Therefore, the use of working level monitors and any conversions between pCi/L and WL will be subject to the conditions described in Appendix B, and the use of radon decay product measurements to make mitigation decisions in Multifamily buildings is not currently supported by this standard.

1.3.3 Other special considerations. See 3.6 and 3.7 for discussions of situations that may indicate when additional steps beyond minimum protocols are appropriate for consideration.

2.0 Preparing for the Measurement

2.1 Devices and personnel:

2.1.1 All devices used for measuring radon in buildings shall meet state requirements and be approved by NEHA-NRPP or NRSB. All devices shall be used in strict accordance with manufacturers instructions.

2.1.2 Consult the manufacturer to determine whether the devices are capable of measuring over the chosen deployment period.

2.1.3 In addition, individuals who place or analyze radon measurement devices shall meet state licensing requirements or should be certified by the NEHA-NRPP or NRSB.

2.1.4 For large testing projects, additional Quality Control procedures should begin prior to deployment. (See 5.0 and 5.4 below.)

2.2 Prior Notification and Closed-building compliance. Control test conditions prior to and during testing. Maintain ***closed-building protocol*** for short-term tests.

2.2.1 **Ensure Occupant Notification:** Failing to comply with required conditions is most likely to occur when residents are not properly informed about the necessary test conditions.

2.2.1.1 Determine whether the building is new, occupied, and who will be responsible for closed-building conditions prior to and during the measurement period.

2.2.1.2 Prior to placing devices, ensure that an appropriate ***notice of inspection*** is distributed to residents at least two weeks in advance of testing and again a few days prior to the test for both tested and non-tested locations. (See example Exhibit 5 and Exhibit 8.) This will also help residents become familiar with the purpose and dates of testing.

2.2.1.3 Upon initiation of a short-term test, post ***"Radon Survey in Progress"*** notifications in conspicuous locations stating the conditions of the test. (See Exhibit 7.)

2.2.1.4 Request occupant of tested locations sign a ***non-interference statement form.*** (See Exhibit 6.) This can also help ensure that the occupant was able to comply with the required conditions and did not tamper with the test devices or conditions.

2.2.1.5 It is also recommended to request signatures on a ***non-interference statement form*** from occupants of **all** other locations not being tested in the building. (See Exhibit 9.)

3.0 Where to Test

3.1 Conduct a measurement in each ground contact apartment, dwelling and those rooms that are used as office space. This means each unit that has floor(s) and/or wall(s) in contact with the ground or is over crawlspaces, utility tunnels or parking garages.

Within each dwelling, test a room located in the lowest livable level that is in contact with the ground or above a crawlspace, utility tunnel or garage. If the lowest level is not currently used but could serve as a den, playroom, office, work area or an additional bedroom at some time in the future, conduct a test in this level.

(See placement example diagrams in Exhibits 1a and 1b.)

3.2 Also conduct a measurement in non-residential ground-contact rooms or areas (e.g. utility rooms, storage rooms, and maintenance rooms) that:

- are occupiable with little or no modification; or
- have air communication with occupiable areas (e.g. stairwells and elevator shafts).

When in doubt, test the area. Results from testing these unoccupied areas provide assurance regarding current or future use of the building, and they may indicate a need for additional testing in upper areas. These unoccupied areas may serve as a pathway for radon into apartments and offices of upper floors.

3.3 For large rooms or open areas – Place one detector every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length).

3.4 On the upper floors, conduct a measurement in at least one apartment on each floor; include measurements in at least 10 % of the dwellings on each of the higher floors. It is recommended that the upper floor test locations be selected so that units on one floor are not directly above or below units being tested on other floors. (See placement example diagrams in Exhibit 1c.)

3.5 Test all areas during the same time period (days or phase).

3.6 Additional Protocols depending upon Heating, Cooling and Ventilation Systems:

Table 3.6
(See Exhibit 1-d and 1-e for graphic illustration.)

Group 1: Basic Heating and Cooling **A dedicated system for each dwelling that does not supply additional fresh air for ventilation.** • **Forced-air** heating and air conditioning (HAC) systems (such as normally seen in single-family residences). • **Ductless Systems** - Non-Forced-Air Hot and Cold Water Circulation (sometimes called radiator systems). - Window AC or Unit Ventilators (w/fresh air closed). - Wall or Baseboard heating/cooling. • **Ductless Split Systems:** One system for cooling and one system for heat (i.e. Window AC for cooling and Baseboard heat). *(No additional requirements. See 3.6.1)*
Group 2: Multi-zone Systems Independent systems and controls for different areas within the same dwelling. *(Additional test locations may be required. See 3.6.2)*
Group 3: Variable Distribution and Ventilation • Systems where the airflow from a single air handler is distributed to multiple dwellings or locations with independent controls within each dwelling for duct dampering. Such systems include Variable Air Volume (VAV) systems or systems with fixed volume return vents and controls for dampering supply air. • Systems that add fresh air ventilation (HVAC). Such systems may exist for service to a whole building, multiple dwellings or as single unit ventilators. *(Additional protocol requirements. See 3.6.3 and 4.4)*

If you are unsure as to the type of system that is present, consult with the building representative, a mechanical engineer or a heating and air-conditioning contractor..

If additional test locations are warranted, preferred rooms are ground contact bedrooms and any rooms that can be closed off from the main part of the dwelling. When in doubt, test the area.

3.6.1 Group 1: Basic Heating and Cooling. (See Exhibit 1-d.) No additional test locations are required within the dwellings where each dwelling has a dedicated system that does not supply additional fresh air for ventilation.

3.6.2 Group 2: Multi-zone systems. Place enough additional detectors in ground contact rooms within the dwelling to adequately characterize and record differences between rooms within the same dwelling that are serviced by different systems. (See Exhibit 1-d.)

3.6.3 **Group 3: Variable Distribution and Ventilation.** These systems can cause radon concentrations to vary widely from test to test (or room to room) based upon normal variation in system operation. (See Table 3.6 above and Exhibit 1-e for graphic illustration.)

For Group 3 systems: Place both a long-term and a short-term detector simultaneously in each ground contact test location (see 3.1 through 3.4 above) and in additional locations within each dwelling to ensure that each bedroom, general living area and any other major area that can be closed off from the main part of the dwelling has been tested. (See 4.4 for additional details.)

3.7 Testing in Areas with Geologic Considerations:

Local geologic and topographic characteristics have been correlated with unusual or sizable variations in indoor radon concentrations. If a foundation is connected to a sub-surface cavity system, which connects to the radon-producing strata, large variations can occur. The most common examples are buildings found in limestone-rich areas where groundwater has eroded passages in the underlying rock (*karst*) or areas with faulting which could allow radon to be transported in an unusual manner.

Structures in regions where these geologic characteristics exist have been shown to have the potential for wide variations in radon concentrations. Confirming low results by repeating tests during different seasons and weather conditions or with long term testing is especially important for such regions.

Radon offices in some states may have information on the presence of geologic characteristics that can create unpredictable radon entry behavior. If you are uncertain whether these conditions exist in your area, contact your State Radon Office.

3.8 Choosing a location in a room

The following criteria shall be used to select a location in a room to place detectors:

3.8.1 Place the detectors within the general ***breathing zone***. Locate the detectors **no less than**:

- Three feet (90 centimeters) from exterior doors and windows or other potential openings to the outdoors
- One foot (30 centimeters) from the exterior wall of the building
- 20 inches (50 centimeters) from the floor
- Four inches (10 centimeters) from other detectors and surrounding objects or as recommended by the manufacturer or laboratory.
- For those detectors that may be suspended, an optimal height is no higher than eight feet (2.5 meters) from the floor and a minimum of one foot (30 centimeters) below the ceiling.

3.8.2 Select a position where the detectors will not be disturbed during the measurement period. The detectors must not be moved, covered or have their performance altered during the test.

3.8.3 *Do not* place detectors inside closets, crawlspaces or hallways or in enclosed areas of high humidity or high air velocity. The latter may include kitchens, laundry rooms, and bathrooms.

3.8.4 *Do not* place detectors inside cupboards, sumps, or nooks within the building foundation.

3.8.5 *Do not* place detectors near drafts caused by heating, ventilating and air conditioning vents, or fans.

3.8.6 *Do not* place detectors near heat sources, such as on appliances, near fireplaces or in direct sunlight.

3.8.7 *Avoid* placing detectors on or near furnishings made of or containing natural stone, e.g. granite counters, hearths or slate pool tables.

4.0 Testing Strategies

Any of the following test strategies may be employed for testing structures whether conducted for non-real estate purposes or when associated with a real estate transaction. Tests conducted for an individual dwelling, condominium or co-op unit may employ these strategies yet conditions that meet the requirements of 6.0 below (Conditions required before and during the test) are still required for the whole building when short-term detectors are deployed.

See Appendix E "Project Plan: Procedural Checklist For Testing" and illustrations in Exhibits 1-2 for calculating the number of test detectors that will be needed for each strategy option.

Acceptable strategies:

A. **Extended** Test Protocol *(corresponding to EPA's Citizen's to Guide to Radon or latest comparable EPA document for homeowners and non-real estate situations)*. (See Table 4.1 and Flowchart Figure 1.)

The ***Extended testing protocol*** entails a quick and cost-effective initial test with follow-up testing in locations where elevated radon concentrations were initially measured. The ***Extended testing protocol*** is an option when time constraints are not prohibitive and when occupant relations allow the performance of a second test when needed. Follow-up tests may be short-term tests or, when initial tests indicate concentrations of 4 to 8 pCi/L (148 to 296 Bq/m^3), long-term follow-up tests may be employed to provide a better understanding of the year-round average radon concentration for those occupants and to be more certain that you should mitigate. There are still health risks at radon concentrations below 4 pCi/L (148 Bq/m^3) and long term retesting should be considered if results are between 2 and 4 pCi/L (74 to 148 Bq/m^3).

B. The **Time-Sensitive** test protocol (*corresponding to EPA's Home Buyer's and Seller's Guide to Radon or latest comparable EPA document)* (See Table 4.2 and Flowchart Figure 2.)

Time-Sensitive testing protocols require additional controls to aid reliability of results during a single phase of testing. ***Time-Sensitive testing protocols*** may be appropriate for situations where quick decisions are needed or when other strategies are unacceptable. Time-sensitive situations may include: real estate transactions; planned renovations; or other situations that require a quick evaluation of whether radon mitigation is needed. Options provided in this protocol might also be desired when logistics or public relations with occupants render other strategies unacceptable (i.e. when occupants might consider repeated access and closed-building requirements to be disturbing intrusions into their homes).

C. Special considerations are outlined for **Retests after mitigation** (see 4.3) and **Buildings with Group 3: Variable Distribution and Ventilation HVAC Systems.** (See 3.6, 4.4 and Exhibit 1-e.)

4.1 Extended Protocol

Table 4.1

Extended Testing Protocol (corresponding to EPA's Citizen's Guide to Radon for homeowners - non-real-estate circumstances)	
TYPE OF TEST (passive devices)	*What to do next if the test result is 4.0 pCi/L or greater*
Single Short-Term Test	*Test this location again ** **If the first short term test is 8.0 pCi/L or greater, conduct a second short-term test immediately. If the first short term test is 4.0 to 8.0 pCi/L, conduct either a short term or a long-term test.*
Average of 2 Short-Term Tests	*Fix the building* *Consider fixing between 2.0 and 4.0 pCi/L*
A Long-Term Test	*Fix the building* *Consider fixing between 2.0 and 4.0 pCi/L*
Less than 4.0 pCi/L: Confirm the low result by testing again every five years and whenever significant changes to the building's structure or mechanical systems occur. Testing during a different season and different weather conditions or with long-term testing is recommended.	

(See Figure 1: Extended Testing Protocols.)

4.1.1 **Step 1: Initial Measurements**:

Conduct initial measurements under closed uilding protocols (see 6.0) for at least 48 hours using short-term tests (i.e. 2 to 90 days) to provide a quick answer to whether high radon concentrations are present.

Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

4.1.1.1 ***Quality control:*** The required number of duplicate measurements is at least **10 percent** of all the testing locations. The number of blank measurements needed is equal to **5 percent** of all the testing locations. (See 5.0 below for additional quality control requirements including spiked measurements and Appendix A for additional information.)

4.1.2 Step 2: Follow-up Measurements

Do not use the results of a single short-term passive test detector as the basis for determining whether to mitigate an area.

Conduct a follow-up test, at a minimum, in every testing location with an initial short-term test result of 4 pCi/L (148 Bq/m^3) or greater. Test additional locations as necessary, e.g. invalid tests from the original testing series, other locations surrounding original elevated locations, and locations or pathways that may influence elevated radon concentrations in the building. All follow-up measurements should be initiated during the same time period (or phase) and placed in the same locations as the initial measurements.

4.1.2.1 Use a *short-term, follow-up* test if results are needed quickly.

The higher the initial short-term test result, the more certain you can be that a short-term follow-up test should be used rather than a long-term follow-up test.

If the initial short-term measurement for a testing location is 8.0 pCi/L (296 Bq/m^3) or greater (twice the EPA's radon action level of 4 pCi/L [148 Bq/m^3] or more), a short-term follow-up measurement should be taken immediately. Use the average of the initial and follow-up test results to determine if this location needs mitigation.

All short-term tests should produce results in the same measurement units and to the extent possible, should be made in the same locations and under the same conditions as the initial tests.

4.1.2.2 Use a *long-term, follow-up* test to better understand the year-round average radon concentration and to be more certain that you should mitigate.

For a better understanding of your year-round average radon concentration or when an initial test indicates 4.0 to 8.0 pCi/L (148 to 296 Bq/m^3), you may consider a long-term follow-up test conducted as close to a year as possible ensuring that the test period includes multiple seasons one of which is a heating season. Long-term tests must be deployed for *a minimum of 91 days* and closed-building conditions are not required for test periods lasting longer than 90 days. You may use the result of this test to determine if this location needs mitigation.

4.2 Time-Sensitive Protocol

4.2.1 Time-Sensitive Measurement Options:

These measurement strategies involve a single phase of testing and therefore require additional controls to ensure reliability of results when making mitigation decisions based upon a single phase of testing.

Table 4.2

Time-Sensitive Testing Protocols
(corresponding to EPA's "Home Buyer's and Seller's Guide to Radon")

TYPE OF TEST	*What to do next if the location is 4.0 pCi/L or greater*
Passive Devices: *(Passive devices do not provide hourly measurements)* **Simultaneous Testing**: Conduct two short-term tests at the same time in the same location for at least 48 hours. Locate detectors no less that 4 inches (10 centimeters) from other test devices and surrounding objects or as recommended by the manufacturer or laboratory. **Average the results**.	*Fix the building if the average is 4.0 pCi/L or greater* *Consider fixing between 2.0 and 4.0 pCi/L*
Continuous Monitor (Active) Devices: *(These devices provide hourly measurements.)* Test the room with a continuous monitor for at least 48 hours.	*Fix the building.* *Consider fixing between 2.0 and 4.0 pCi/L*

(See Figure 2: Time Sensitive Testing Protocols)

4.2.1.1 Simultaneous Testing: Conduct the measurement at each location with two short-term passive test detectors at the same time in the same location for at least 48 hours under closed building protocols. (See 6.0 below.) Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

Locate devices no less that 4 inches (10 centimeters) from other test devices and surrounding objects or as recommended by the manufacturer or laboratory. The results of both measurements should be reported. Use the average of the two results to determine if this location needs mitigation.

4.2.1.1.1 *Quality control:* This option results in **100 percent** duplicates. The number of blank measurements needed is equal to **5 percent** of all the testing locations. (See 5.0 below for additional quality control requirements including spiked measurements and Appendix A for additional information.)

4.2.1.3 Continuous Monitor devices: A continuous monitor is capable of providing and averaging reviewable hourly readings. Conduct short-term tests for at least 48 hours under closed building protocols. (See 6.0 below.) Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

This option may only be cost-effective for very small building complexes. However, continuous monitors might be chosen for areas of the building(s) where a more detailed assessment of radon fluctuations is appropriate (i.e. locations where significant fluctuations in pressure or ventilation might be expected). Use the average result of this test to determine if the location needs mitigation.

4.2.1.3.1 *Quality control:* The required number of duplicate measurements is at least **10 percent** of all the testing locations. (See 5.0 below for additional quality control requirements and Appendix A for additional information.)

4.3 Retests after mitigation

To provide an initial measure of radon reduction system effectiveness, conduct a short-term measurement no sooner than 24 hours after a radon reduction system is operational and within 30 days after installation of system. Conduct the post-mitigation testing in the areas that were mitigated and in the same locations as the pre-mitigation test locations.

Conduct post-mitigation testing in all locations where elevated radon was found in the initial testing phase.

Conduct additional testing in the areas that were mitigated at least every two years to ensure that the system remains effective. Testing may be conducted as often as desired.

4.4 Testing Strategy for Buildings with Group 3: Variable Distribution and Ventilation HVAC Systems. (See 3.6, Table 3.6 and Exhibit 1-e.)

Place both a long-term and a short-term detector simultaneously in each test location (see 3.6.3). Deploy detectors in accordance with 4.1.1.1 (Quality Control) for each detector type and short-term detectors in accordance with 4.1.1 (Initial Measurements).

If all results from short-term testing are below the action level, use only the results from long-term detectors for decisions to mitigate.

If any short-term test result is above the action level, continue to use the results from long-term detectors as the most reliable measurement for decisions to mitigate, unless occupant safety or time constraints are paramount. (See Section 4.4.1 below.)

Deploy long-term test devices for the following time periods to determine the need to mitigate:

- If the highest short-term test result is 10 pCi/L (370 Bq/m^3) or greater, leave all the long-term detectors in place for at least 91 days.
- If the highest short-term test result is 4.0 pCi/L (148 Bq/m^3) or greater but less than 10 pCi/L, (370 Bq/m^3) leave all the long-term detectors in place for at least 180 days.
- If the highest short-term test result is less than 4.0 pCi/L (148 Bq/m^3), leave all the long-term detectors in place for one year.

4.4.1 If short-term results cause concern for occupant safety or where time constraints are paramount, a follow-up short-term test that corroborates the initial elevated reading(s) may present enough information to mitigate. In this situation, test in accordance with 4.1.2 (Step 2: Follow-up Measurements). If follow-up readings do not corroborate the initial elevated readings and consideration has been applied towards helping ensure tests were conducted properly, use the results of the long-term measurement to make a mitigation decision. Note that Multifamily buildings with Group 3 mechanical systems render short-term test strategies less likely than a long-term test to reflect a year-round average radon level or to correctly indicate the need for mitigation.

5.0 Quality Control In Testing Multifamily Buildings

Testing requires an overall quality assurance plan for tracking precision and bias that includes duplicate, blank and spiked measurements. (See Appendix A.) These requirements apply to both short-term and long-term devices. Evaluate and report these measurements as they represent an "early warning system" to identify problems that may have developed during the testing of Multifamily buildings. Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project.

5.1 Blanks and duplicates shall be part of a radon measurement professional's quality assurance plan and shall be included in the final report documentation (see 8.5.4).

Table 5.1

General Quality Control Measurements	
Duplicate Measurements (side-by-side detectors)	**Blank Measurements** (unexposed detectors)
The number of duplicate measurements shall be equal to or greater than 10% of all testing locations (or as specified by the test strategy chosen.) See 4.0 above.	The number of blank measurements shall be equal to 5% of all testing locations. Field blanks (blanks deployed at the testing location) are not required. However, allocating 3% field blanks and 2% office/laboratory blanks is recommended.

See APPENDIX A for additional information on QC.

5.2 Field blanks are generally not required to be deployed at the testing site. However, radon measurement professionals should consider deploying 3% field blanks and 2% office blanks to evaluate background exposures throughout the sampling process. Office blanks remain in the office setting. Field blanks are taken to the site and left on site to parallel sampling conditions.

5.3 **Special considerations for blank detectors in large deployments.** As the number of units to be tested in a complex increases, the need for specialized blank procedures also becomes greater. With a larger number of testing locations and detectors, the investiture of time and money for the client and the radon measurement professional becomes great enough that an early detection procedure should be included in the blanks deployment protocol.

Table 5.3

Additional QC Measurements for Larger Projects
At a minimum of 50 test detectors deployed, testers should increase the number of blanks to 9 detectors:
• 3 *Laboratory* blanks should be returned to the laboratory immediately to evaluate quality prior to beginning detector deployment. These detectors serve both to evaluate the quality of the laboratory and any unexpected exposures that might result from shipping or handling;
• 3 *Office* blanks should remain in office locations where detectors are stored or handled and then returned to the laboratory with the sampling detectors per normal procedure for field detectors, These detectors serve to evaluate any unexpected exposures that might result from storage, and handling;
• 3 *Field* blanks should be deployed in the field with the sampling detectors and be returned to the laboratory per normal procedure for field detectors. These detectors serve to evaluate any unexpected exposures that might result onsite or from handling procedures.
If more than 180 test detectors are deployed, the standard 5% blanks number can be resumed, however, the practice of using pre-test blank evaluation and office plus field blanks should be continued.
NOTE: Consult with the manufacturer/laboratory to insure detector-specific procedures approved by the manufacturer/laboratory are used when conducting blank measurements.

See APPENDIX A for additional information on QC.

5.4 **Spiked measurements and special considerations for spiked measurements in large deployments.** Spiked measurements for the testing project (or from the radon measurement professional's ongoing QC plan) shall also be included in the final report documentation (see 8.5.4). As the number of units to be tested in a complex increases, the need for specialized spike procedures also becomes greater. With a larger number of testing locations and detectors, the investiture of time and money for the client and the radon measurement professional becomes great enough that an early detection procedure should be included in the spike protocol.

At a minimum of 100 units to be tested, testers should ensure that the result of three spiked detectors from the sampling program batch have been received and are satisfactory (±25 % of the reference value) prior to beginning the sample deployment.

6.0 Conditions required before and during the test

Long-term tests (those lasting 91 days or more) do not require closed-building conditions. Long term tests should be conducted as close to a year as possible ensuring that the test period includes multiple seasons (one of which is a heating season).

Short-term tests conducted for two days to 90 days require **closed-building conditions.**

Purpose of Closed-building Conditions: Closed-building conditions are required for short-term measurements to stabilize radon concentrations and entry rates and increase the reproducibility of the measurement. Without these controlled conditions, measurements can indicate higher or lower readings than are typically present.

6.1 Closed-building Protocol

- ❖ Closed-building conditions shall be maintained throughout the test period and for 12 hours prior to the initiation of measurements lasting less than four days
- ❖ All windows on all levels of the building shall be kept closed and all external doors shall be kept closed (except for momentary entry and exit). This includes areas not being tested.
- ❖ Heating and cooling systems shall be set to normal, occupied, operating temperatures; fan/blower controls shall be set to intermittent activity unless the system is designed to only run the fan continuously.
- ❖ Whole house fans shall not be operated.
- ❖ Occupants should avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air into and out of the building.
- ❖ Solid, liquid, or gas fuel burning fireplaces shall not be operated unless they are the primary/normal sources of heat for the dwelling.

6.1.1 Additional closed-building requirements

- Window air-conditioning units shall only be operated in a re-circulating mode.
- Equipment that supplies fresh air to the dwelling shall be deactivated unless it is an integral part of the HVAC system or supplies make-up air to a combustion appliance.
- Window fans shall be removed or sealed shut.
- Fans installed in attics to control only attic air and not whole-building temperature or humidity may continue to operate.
- Air exchangers: Normal operation of permanently installed ventilation systems such as energy recovery ventilators (also known as heat recovery ventilators or air-to-air heat exchangers) may continue during closed-building conditions so long as the system is regularly maintained and continuously operational. If such a system is labeled or intended to serve as a radon control system, see 6.2 below: Special considerations, Radon Mitigation Systems.
- **New construction, renovations and repairs:** Items that shall be completed or installed before the radon test is initiated include:
  - all insulation,
  - all exterior doors and hardware,
  - all windows,
  - all fireplaces and fireplace dampers,
  - all heating/cooling appliances (functioning and set to run at normal occupied temperatures),
  - all ceiling coverings,
  - all interior trim and wall coverings,
  - all exterior siding, weatherproofing and caulking.
  - structural openings to the **exterior** as a result of incomplete construction, structural defect, disrepair, or the like shall be closed or repaired 12 hours prior to initiating the test.

6.2 Special considerations

- **Severe Weather:** Short-term tests lasting less than four days should not be conducted during unusually severe storms or periods of unusually high winds.
- **Radon Mitigation Systems:** Prior to beginning a test, a permanently installed active radon reduction system shall have been operating for at least 24 hours and shall continue to operate during the test period. In addition, closed-building conditions shall be

maintained 12 hours prior to initiating a valid test period and throughout test.

6.3 Detector Deployment Periods

6.3.1 Short-Term Detectors: Short-term detectors shall be deployed for two to 90 days.

Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

Since terminating a measurement at exactly 48 hours is often impractical, some flexibility is allowed. For example, for integrating or equilibrating devices, retrieval of detectors after 46 hours is allowed (assuming Closed-building Protocol requirements are met). For continuous monitors, the first four hours of data may be discarded or incorporated into the result using system correction factors (EPA 402-R-92-004; EPA 1992). There must be at least 44 **contiguous** hours of usable data to produce a valid average. The "backing out" of data (i.e., removal of portions imbedded in the two days) to account for weather or other phenomena will invalidate the measurement. The periodic results shall be averaged to produce a result that is reported to the client and used to make mitigation decisions.

Termination of a short term test that is longer than two days should be done as close as possible to 24-hour increments to help ensure diurnal fluctuations in radon concentrations within a dwelling are reflected in the results evenly.

6.3.1.1 If a monitor cannot integrate readings each hour or less or is not set to record readings each hour or less, **then it is functioning as an integrating device and is not considered a continuous monitor** under these protocols.

6.3.1.2 Radon decay product measurements require additional controls for closed building test conditions when used to make radon mitigation decisions. At this time, existing documents and science were not found to adequately address these considerations and several related concerns. Therefore, the use of radon decay product measurements to make mitigation decisions in Multifamily buildings is not currently supported by this standard. The use of radon decay product measurement devices and any conversions between pCi/L and WL will be subject to the conditions described in Appendix B and as amended over time.

6.3.2 Long-Term Detectors: Long-term detectors shall be deployed for a minimum of 91 days. It is recommended that they be deployed for a minimum of six months over different seasons (one of which is a heating season) **or** as close to a year as possible to reflect seasonal changes in radon concentrations and building operation. This is especially important for dwellings that are serviced by heating and cooling systems based upon variable distribution and ventilation (See 3.6.3, Table 3.6 and Exhibit 1-e). Closed-building conditions are not required, but are recommended. State Radon Offices may have information on seasonal variation.

6.4 Test Condition Verification:

The test should include methods to prevent or detect interference with testing conditions or the testing detector. The radon measurement professional or occupant should be able to verify or provide documentation asserting that testing conditions were not violated during the testing period. A test company's minimum requirements for verifying test conditions shall be fulfilled by the following:

6.4.1 Informing the person responsible for building operation of the required test conditions;

6.4.2 Obtaining or attempting to obtain a signed noninterference agreement;

6.4.3 Posting a *Radon Test in Progress* notification form;

6.4.4 Conducting a visual inspection of the dwelling upon placement to assure all closed-building conditions are intact;

6.4.5 Conducting a visual inspection of the dwelling upon retrieval of the detector including:

6.4.5.1 Maintenance of closed-building conditions,

6.4.5.2 Changes in the detector placement,

6.4.5.3 Condition of all tamper seals (see 6.5).

6.4.6 The radon measurement professional is not responsible for inspecting for closed-building conditions 12 hours before the start of the test or between placement and retrieval of the detectors.

6.4.7 If, at the initiation of the test, the radon measurement professional discovers or observes that closed-building conditions have not been maintained, one of the following options is required:

- The radon test can be postponed until at least twelve hours of closed-building conditions have been maintained prior to the test;
- The radon test period can be extended to four days or more with an appropriate detector after closed-building conditions are initiated;

- For continuous monitors, detector features or methods may be used to obtain an average reading that represents at least 48 hours of contiguous data collected after at least twelve hours of closed-building conditions have been maintained (e.g. a test may be run for 60 hours, the first 12 hours discarded and the last 48 averaged manually).

6.5 Other controls and aids for detecting failed compliance or interference

- *Placement Indicators:* A position for the detector can be chosen and noted so that, upon retrieval, any handling or covering of the detector can be detected.
- *Seals:* Non-re-sealable caulks and/or tapes can be used to verify that detectors have not been altered or moved; in addition, they can be used to verify that windows or non-primary exterior doors have not been opened during the test. If broken, seals may help determine if testing conditions were altered or a detector was disturbed. For a seal to be effective:
  - The seal must adhere readily to a multitude of surfaces yet be easily removed without marring the surface;
  - It needs to be non-re-sealable or show evidence of disturbance;
  - It must be unique enough to prevent easy duplication; and,
  - It should be visible enough to discourage tampering.

  Most paper or plastic tapes and caulks have only some of these qualities. There are, however, a number of seals manufactured specifically for radon testing. It would be advisable to use one of these products and follow the manufacturer's recommendations for installation. The best caulking to use as a seal is a removable weather-stripping caulk. This type of caulking adheres readily to most surfaces yet comes off easily without leaving a mark or being re-sealable.
- *Control Monitors:* The inclusion of at least a few detectors that provide hourly data indicating fluctuations in radon can aid confidence that no unusual conditions affected the measurement results. Hourly data for fluctuations of environmental factors such as temperature, humidity and barometric pressure can also aid identification of unusual conditions.

7.0 Special Consideration for Large Disagreement between Duplicate (or Collocated) Results.

Minor variation between the results of duplicate detectors is typical. However, if the variation is unusually large, it may indicate problems in the measurement system which could adversely affect the entire testing series.

One situation requires special attention: Where one test result is 4.0 pCi/L (148 Bq/m^3) or greater and the test result of the collocated detector is less than 4.0 pCi/L (148 Bq/m^3), **if the higher result is twice or more the lower result, a repeat test is required.** (See Appendix A for additional information on Duplicate results.)

8.0 Documentation

The detector placement log and supporting documentation shall be maintained for at least six (6) years after testing. Sufficient information about each measurement shall be recorded in this permanent log to allow for future comparisons, interpretations, and reporting to residence managers.

Final report documentation shall include:

8.1 **Test Site:** The address of the building(s) tested, including zip code.

8.2 **Testing Service information:**

8.2.1 The company/measurement professional's name, contact information and current certification ID number or equivalent state license ID number as applicable,

8.2.2 The name and identification number of the service or organization used to analyze detectors.

8.3 **State Radon Office contact information.**

8.4 **A summary of measurement results** and a statement outlining any recommendations concerning actions for retesting or mitigation. Interpretations and recommendations both written and verbal should reflect guidance provided in the "Introductory Guidance to Residence Managers" (attached above) and shall be provided in accordance with the latest versions of EPA's *Home Buyer's and Seller's Guide to Radon,* EPA's *Citizen's Guide to Radon,* or as recommended or required by the State Radon Office for the location of buildings being tested.

8.5 **The report shall contain all valid individual measurement results.**

8.5.1 When using continuous radon monitors, hourly readings shall be included.

8.5.2 Measurements made in separate locations shall NOT be averaged. They must be reported individually.

8.5.3 Radon gas results reported in picocuries per liter (pCi/L) shall be reported to only one figure after the decimal (e.g. 3.2 pCi/L). The average of collocated measurement detectors shall be reported as well as the individual results. (Note: If the average of two measurements produces a result of 3.95 pCi/L, standard mathematical rules should be followed and such average shall be reported as 4.0 pCi/L.)

8.5.4 All quality control measurements shall be reported as such.

8.5.5 Any reports or test data acquired from residents who have independently tested.

8.6 **Detector and location information:**

8.6.1 Documentation of the locations of all detectors deployed. It is advisable to diagram the test area noting the location and measurement results of the detector. Supplemental photographic records for test locations are advised. (See Exhibit 3 for an example *detector placement log*.)

8.6.1.1 Include documentation regarding locations that should have been tested, but were not tested, with an explanation of the reasons why tests were not conducted.

8.6.1.2 Include documentation of missing, lost and non-retrievable detectors.

8.6.2 The exact start and stop dates and times of the measurement exposure period.

8.6.3 A description of the devices and detectors used including identification/serial numbers.

8.6.4 A record of quality control measures associated with the test such as results of duplicate and blank measurements.

8.7 **Test Conditions**
The Report shall contain sufficient information to allow clients to evaluate the data, interpretations and also make comparisons to any previous or future tests.

8.7.1 **Protocol Conditions:** Include a description of any observed deviations from appropriate measurement procedures that may affect the measurement results.

- Observed non-compliance with or deviations from required conditions such as closed-building conditions, prior to or during the test period.
- Observed deviation from a normal occupied temperature.
- Changes in the detector's placement, whether any seal has been altered or test interfered with.
- Any observed anomalies in data printed from a continuous radon monitor that may indicate interference with the detector or test conditions or non-standard testing conditions.
- A description of any unusual or severe weather conditions.

8.7.2 **Non-interference controls**

- Include a description of any non-interference controls used such as tamper seals, control monitors or other methods.
- Include information on whether the responsible individual signed the noninterference agreement.
- Include copies of signed noninterference agreements.

8.7.3 **Mitigation System Status** (if applicable)

- The test company shall include a statement in the test report if a mitigation system was observed in a dwelling during the placement or retrieval of the detector(s);
- Whether the mitigation system fan was operating;
- A statement may be included in the report that the test company offers no findings as to the proper operation of the system.

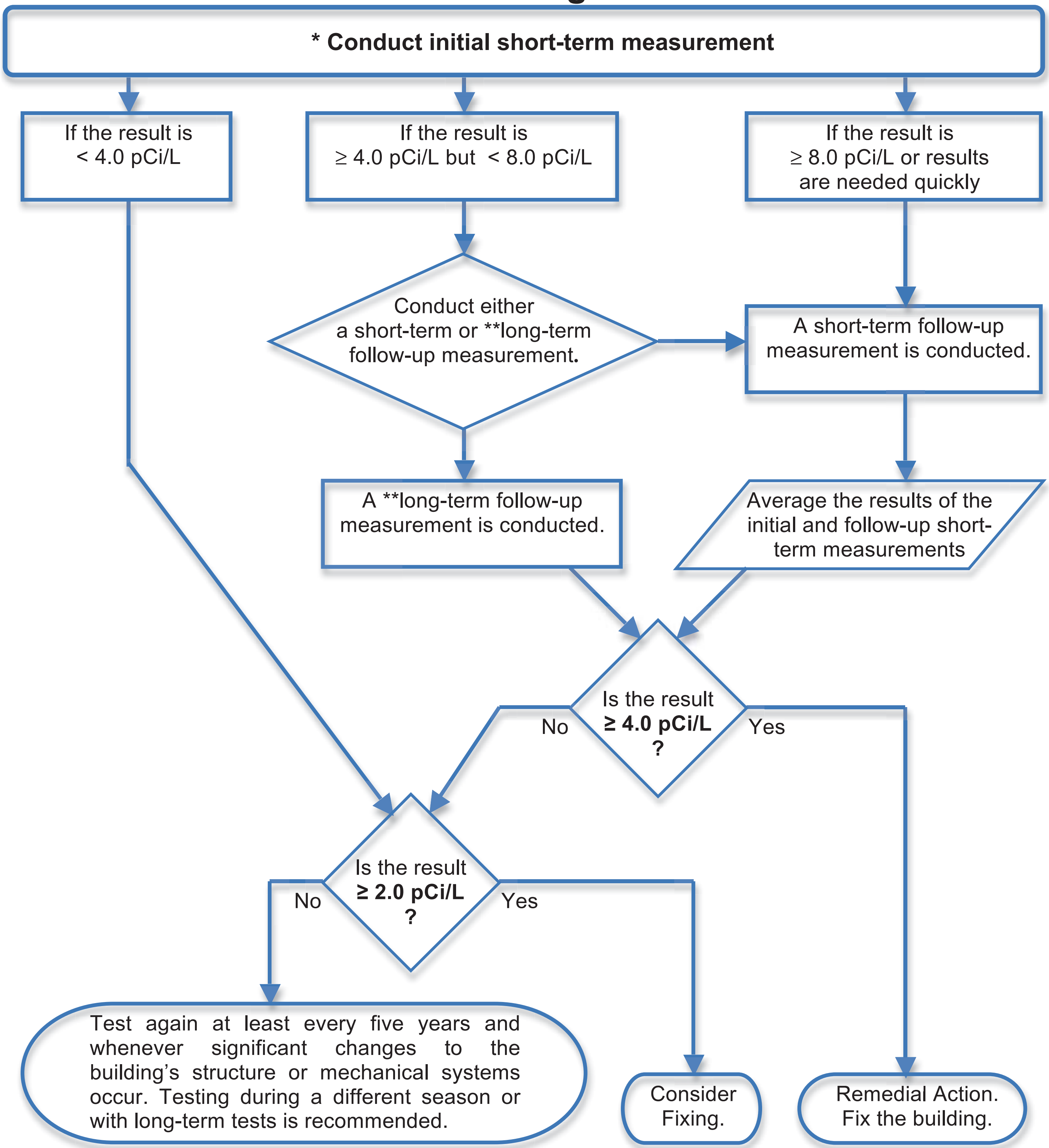
8.7.4 **Temporary Conditions**: Include a description of observed building conditions or other factors that are temporary in nature and may affect the measurement results. The report shall also document for the client that the test may not reflect the client's risk from radon if such conditions are altered from the condition existing during the test period. Temporary conditions include:

- Units that were tested and vacant during the test period;
- The condition of any temporary radon mitigation methods that are not permanent installations;
- The condition of any permanent vents (i.e. open/closed) such as crawlspace vents;
- The condition of active or passive air supplies to the building or to combustive appliances.
- If a permanently installed ventilation system, such as a heat recovery ventilator or air-to-air heat exchanger, is active during the test but ready access exists for deactivation or it functions intermittently.
- Conditions of unusually severe storms or periods of unusually high winds.

8.8 **Statement of Test Limitations**
The report shall describe the general limitations of the test. An example is the following: "There is an uncertainty with any measurement result due to statistical variations and other factors such as daily and seasonal variations in radon concentrations. Variations may be due to changes in the weather, operation of the dwelling, or possible interference with the necessary test conditions."

Figure 1

Extended Testing Protocols

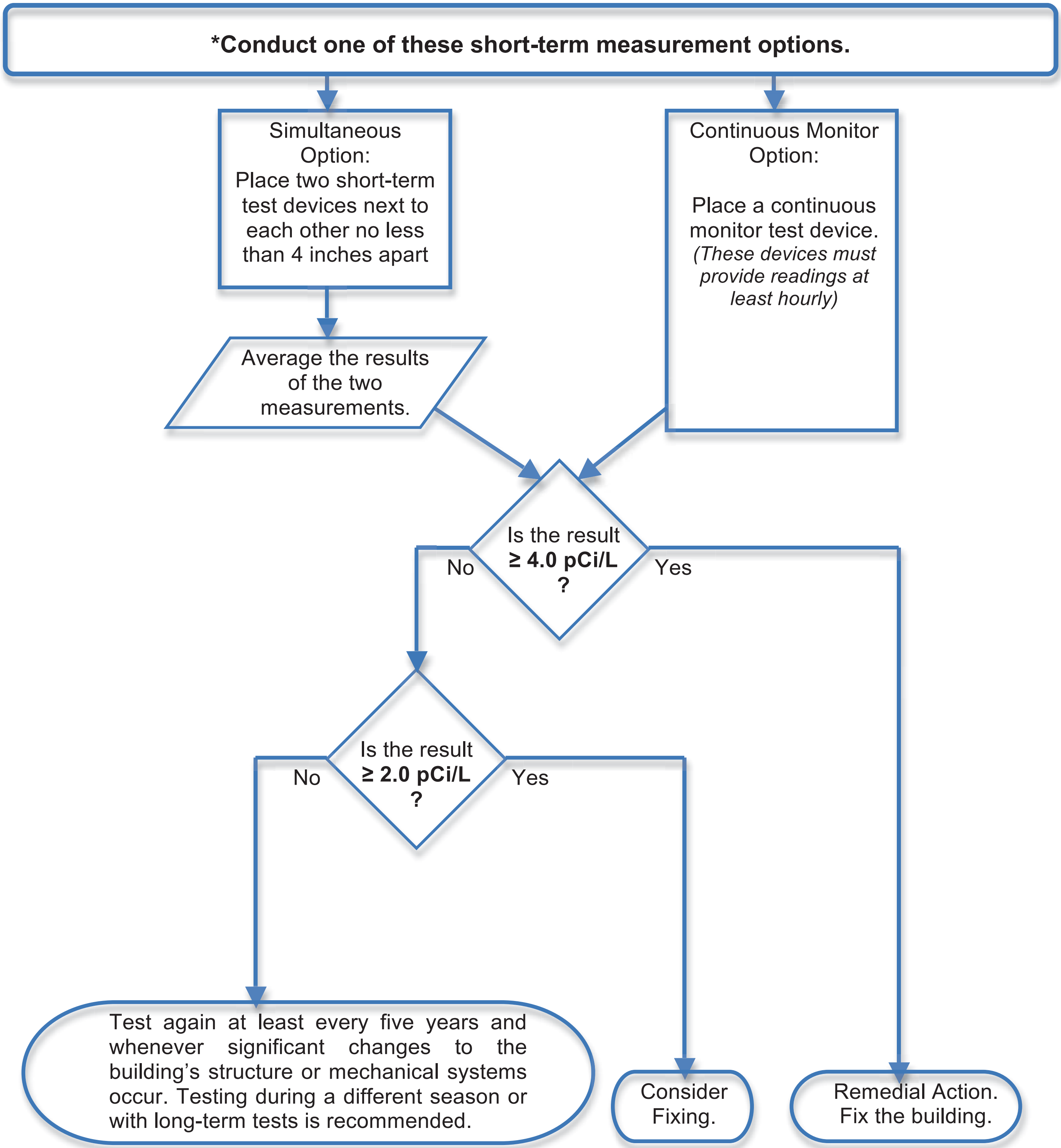


* *Choosing a time of year when closed-building conditions are a normal condition will aid in ensuring reliable measurements.*

** *Long-term tests should be conducted as close to a year as possible ensuring that the test period includes multiple seasons.*

Figure 2

Time-Sensitive Testing Protocols



* *Choosing a time of year when closed-building conditions are a normal condition will aid in ensuring reliable measurements.*

Appendix A

DESCRIPTIONS OF MEASUREMENT DEVICES AND QUALITY CONTROL MEASURES

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

DESCRIPTIONS OF MEASUREMENT DEVICES

Integrating or Equilibrating Devices: A radon measurement system in which the sampling detector, and analysis system often do not function as a stand-alone unit. Integrating devices include electret ion chambers, alpha track monitors, and continuous monitors that are not set to, or are incapable of, recording radon concentration in time increments of one hour or less. Equilibrating devices include activated charcoal kits and liquid scintillation vials. *Integrating* and *Equilibrating* detectors often require laboratory analysis.

Continuous Devices: Test devices that record reviewable measurements of radon or radon decay products (progeny) concentration in time increments of one hour or less.

Abbreviations for Devices referenced in this document

Equilibrating Devices	
AC –	Activated Charcoal
LS --	Charcoal Liquid Scintillation
Integrating Devices	
ES --	Electret Ion Chamber (short-term)
EL --	Electret Ion Chamber (long-term)
AT –	Alpha Track (filtered)
Other Integrating Devices: *Devices not designed or set to record hourly readings.*	
Continuous Devices	
CR –	Continuous Radon Monitor
CW	– Continuous Radon Decay Product Monitor
Other Devices	
Future technologies	

Equilibrating Devices

AC – Activated Charcoal Devices

ACs are equilibrating devices. The charcoal within the detectors has been activated to increase its surface area which increases the ability to adsorb gases. The equilibrating nature of the activated charcoal allows continual adsorption and desorption of radon. During the entire measurement period (typically forty-eight hours to seven days), the adsorbed radon undergoes radioactive decay. ACs should be promptly returned to the laboratory after the exposure period (by service that guarantees delivery within two to three days at maximum). AC detectors are analyzed by gamma-ray spectroscopy which measures the emissions of gamma rays from two short-lived decay products of radon, ^{214}Pb and ^{214}Bi.

LS – Charcoal Liquid Scintillation Devices

Charcoal liquid scintillation (LS) devices are equilibrating devices that function on the same principle as AC devices. LS detectors adsorb radon onto the charcoal in a vial. LS detectors must be resealed and sent to the laboratory for analysis promptly after the exposure period (by service that guarantees delivery within two to three days). They are called “liquid scintillation” devices because they are analyzed by mixing the charcoal containing the radon with an organic “cocktail" and then counting, in a liquid scintillation counter, light pulses emitted due to the emission of alpha and beta particles from radon and its short-lived decay products.

Integrating Devices

EL/ES – Electret Ion Chambers

Electret ion chamber devices (EL/ES’s) are integrating devices that allow radon to diffuse into a chamber through a filter. Radiation emitted from the decay of radon and its decay products produces charged particles (ions) within the chamber. The negative ions are attracted to the positively charged electret and discharge it. The electret is removed from the canister and its voltage measured with a special surface electrostatic voltmeter both before and after the exposure period. The difference between these two voltage readings is used to calculate the average radon concentration.

EL/ES’s are designed to measure for short periods of time (e.g. 2 to 5 days) or for long periods of time (e.g. 9 months). The type of the electret (i.e. short or long-term) and chamber volume determine the usable measurement period. The electret readings are affected by ambient gamma radiation ionizing air inside the chamber, and the readings must be corrected for external gamma-rays.

AT – Alpha Track Devices

An alpha track device (AT) is an integrating device consisting of a small piece of plastic or film (the sensor) enclosed in a housing with a filtered opening. Radon diffuses through the filter into the housing where it undergoes radioactive decay. This decay produces alpha particles that strike the sensor and generate submicroscopic damage called alpha tracks. The damaged portions of the plastic can be made visible by etching in a caustic solution, because the damaged areas are more soluble in caustic than the undamaged plastic. The etched areas can be seen using a microscope. The tracks are typically counted using computer recognition and automated scanning. The number of tracks per unit area is proportional to the integrated average radon concentration in pCi-days/liter. AT's are most commonly used for medium- to long-term tests up to one year in length.

Continuous Monitors

CR and CW – Continuous Radon Monitors and Radon Decay Product Monitors

Continuous monitors use various types of sensors. Some collect air for analysis with a small pump while others allow air to passively diffuse into a sensor chamber. All have electrical circuitry capable of producing and recording integrated radon concentrations for periodic intervals of one hour or less.

Continuous radon monitors measure radon gas. Continuous radon decay product monitors measure radon decay product concentrations and require a pump to sample air containing radon decay products onto a filter assembly.

If a device cannot integrate or record readings each hour or less or is not set to record readings each hour or less, then it is functioning as an integrating device.

Other Devices:

Devices that may be developed that use various other sensors and technologies for integrating data over time. All devices used for measuring radon in buildings shall meet state requirements and be approved by NEHA-NRPP or NRSB. All devices shall be used in strict accordance with manufacturer's instructions.

DEVICE QUALITY CONTROL

Terminology associated with *quality control (QC)* is briefly explained below.

Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project. In lieu of other consensus protocols that may be developed, see EPA Guidance on Quality Assurance (402-R-95-012, October 1997) for details on quality assurance. Additional specific requirements for each device can be found in EPA's "Indoor Radon and Radon Decay Product Measurement Device Protocols." Written Quality Assurance Plans are required of radon measurement professionals and labs who are state licensed or certified by NEHA-NRPP or NRSB.

Duplicate (Collocated) Measurements

Duplicates are pairs of detectors or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between detectors. (Note: Duplicates do not evaluate accuracy; for accuracy, see spiked measurements below.) Duplicates may help identify problems that may introduce error into the test results. Duplicates are typically deployed at a rate of 10% of the measurement locations. When establishing a testing service's overall quality control plan up to fifty duplicates per month are recommended. However, additional duplicate measurement may be required for specific testing programs such as discussed herein for Multifamily buildings.

Field duplicates should provide the same or similar radon results. Duplicate pairs of measurements greater than or equal to 4 pCi/L (148 Bq/m^3) should produce a Relative Percent Difference (RPD) greater than 36% no more than 1% of the time. Greater than 1% duplicates above 4 pCi/L (148 Bq/m^3) with an RPD greater than 36% indicates the measurement system is "out of control," and all measurements are questionable.

See Appendix C "Definition of Terms" for information on calculating the RPD.

If one duplicate is equal to or greater than 4 pCi/L (148 Bq/m^3) and the other below, the higher result may not be twice or more than the other. Such measurements must be repeated.

Blank Measurements

Blanks are integrating or equilibrating detectors that are not intentionally exposed for sampling (i.e. not left open to permit radon to enter the detector during the deployment period). Blanks help evaluate any detector response from sources other than radon exposure at a testing location such as in the manufacturing process or during shipping, storage, analysis and handling.

Blanks are typically deployed at a rate of 5% of the measurement locations. When establishing a testing service's overall quality control plan, up to 25 blanks per month are recommended.

However, additional blank detectors may be required for a specific testing program such as herein discussed for Multifamily buildings. See Section III, subsection 5.0.

Consult with the manufacturer/laboratory to insure detector-specific procedures approved by the manufacturer/laboratory are used when conducting blank measurements. For many detectors, blanks are unwrapped and immediately rewrapped (or momentarily opened and closed) to give the appearance that they have been used in testing. The blanks are then shipped with the exposed detectors so that the laboratory cannot distinguish them.

- *Laboratory blanks* are those returned to the laboratory immediately in order to evaluate laboratory quality yet also serve to evaluate if any unexpected exposures resulted during shipping or handling.
- *Office blanks* are those that remain in office locations where detectors are stored or handled in order to additionally evaluate any unexpected exposures that might result in those locations. Detectors should be stored and handled in a known low-radon environment.
- *Field blanks* are those that accompany the onsite sampling detectors in order to evaluate any unexpected exposures that might result onsite or from handling procedures.

Since blanks are not exposed, their measurement value should be below the lower limit of detection (LLD—the radon concentration below which the measurement system cannot accurately measure). Depending on the device, if one or more results are greater than the LLD, this may indicate defective detectors, poor quality control or improper procedures. If a problem is identified, the detector supplier should be contacted to evaluate and institute corrective procedures.

Spiked Measurements

Spikes are detectors that have been exposed in a NEHA-NRPP or NRSB approved chamber to a known concentration of radon (i.e. "spiked" with radon). Using spiked measurements can help evaluate the accuracy of a laboratory analysis and/or how accurately detectors supplied by a laboratory measure radon.

Detectors from the same batch as those slated for the sampling program are spiked and returned to the laboratory for analysis as near the sampling period as possible. Many detectors are time sensitive and require return to the laboratory for analysis immediately after spiking. In general, spikes are included at a rate of no less than 3 per 100 sampling locations. When establishing a testing service's overall quality control plan, up to six spikes per month and a minimum of three per year are standard operating procedure. However, a specific testing program such as discussed herein for Multifamily buildings may require additional spiked detectors.

The results from spikes are compared to the known value provided by the reference facility where they are spiked using the formula for Relative Percent Error (RPE). The RPE is plotted on a control chart. If the result of a spike differs greatly from the spike's known concentration, it may indicate that the detectors are defective or the laboratory procedures are faulty. EPA 402-R-95-012, *Guidance on Quality Assurance* provides guidance on how to set warning and control limits. In general, the expectation is that the values of RPE fall between +10% and -10%, but the entire range of +20% to -20% is considered "in control." Outside of +/-20% but inside +/-30% is the warning level and outside of +/-30% is the control limit.

See Appendix C "Definition of Terms" for information on calculating Relative Percent Error.

Quality Control for Continuous Monitors

Continuous radon monitors require calibration and background checks within the timeframe recommended and at facilities approved by certification requirements, state licensure requirements or the manufacturer's recommendation, whichever is more stringent. Annual calibrations are commonly a minimum requirement. Cross-checks should be conducted at least every six months. Duplicates using a continuous monitor are to be deployed in 10% of the measurement locations. The agreement of duplicate results are calculated using the RPD as noted above and plotted on control charts. An informal intercomparison with a co-located device that reads in the same units (i.e. pCi/L) can also aid in checking quality.

Appendix B

Radon Decay Product Measurement:

The scope of this measurement standards document includes reconciling previous standards documents and guidance publications and adding updated information that relates to residence measurement in order to achieve a protocol deemed credible by the stakeholder delegates.

Items specific to radon decay product measurements in residences were reviewed and considered in an open forum as well as within the subcommittee of stakeholder delegates. Considerations particular to radon decay product measurements include specific controls for closed building test conditions and specific considerations for reporting test results and any conversions between units of measurement. At this time, existing documents were not found to adequately address these considerations and science has not been presented regarding establishing appropriate conditions for radon decay product measurements in homes.

Therefore, Appendix B has been designated as the location in this document for additional protocols specific to the measurement of radon decay products in residences. Scientific studies delineating appropriate protocols are being solicited for review and evaluation through the stakeholder process. Until completion of that process, the use of radon decay product measurements to make mitigation decisions in residences is not supported by this standard.

NOTICE

The committee is formally soliciting suggestions on the wording of the protocol that will standardize testing conditions in residences sufficiently to provide confidence in radon decay product measurements for residential real estate transactions and consumers' interest, and on wording for appropriately using conversion information and conversion factors. Since a comparatively small pool of existing protocol text exists regarding specific considerations for working level measurements, supporting scientific documentation will be needed for proposed wording in order to maintain the integrity of the document and confidence of those using the protocol.

The committee is looking forward to active participation from all interested parties in developing a protocol that will be respected by stakeholders across the spectrum.

All such submissions must be forwarded to standards@aarst.org or faxed to (913) 273-0134 in order to receive consideration. Submissions will then be posted by AARST staff for workgroup and committee review.

Appendix C

Definition of Terms

Becquerel per cubic meter (Bq/m³):	A unit of radioactivity representing one disintegration per second per cubic meter: 1 Bq/m^3 (0.027 pCi/l).
Blank Measurements:	Blanks are integrating or equilibrating detectors that not intentionally exposed for sampling (i.e. not left open to permit radon to enter the detector during the deployment period). Blanks help evaluate any detector response from sources other than radon exposure at a testing location such as in the manufacturing process or during shipping, storage, analysis and handling. See Appendix A and Section III for more information.
Client:	The individual or parties who hire(s) and/or pay(s) for the radon test.
Collocated:	Two or more simultaneous measurements in the same location, or side-by-side
Continuous Radon Monitor (CR or CRM):	Test devices that are capable of, and set to, record and review radon in time increments of one hour or less.
Crawlspace:	An open area beneath part or all of the livable space of a dwelling that typically has either a concrete slab or dirt floor. The dirt floor may be covered with gravel or a membrane. The crawlspace can have an open height of a few inches to several feet. The crawlspace can be storage space but is not living space, and may or may not be ventilated to the outside.
Duplicate Measurements:	Duplicates are pairs of detectors or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between detectors. See Appendix A and Section III for more information.
Equilibrating detector:	A detector which functions by adsorbing and/or desorbing radon from or to the ambient air until an equilibrium condition is reached between the radon concentration in the detector and the radon concentration in the ambient air. Equilibrating detectors include 1) activated charcoal in containers, such as canisters, bags or trays, which are analyzed in a laboratory using gamma-ray spectroscopy and 2) activated charcoal in containers, such as cartridges or vials, which are analyzed in a laboratory using liquid scintillation spectroscopy.
Exposure time:	The length of time a detector must sample radon to get an accurate measurement. Also called "exposure period," or "duration of exposure."
Extended testing:	An initial short-term test is followed by a short- or long-term test if a radon concentration is found to be elevated. The decision to mitigate is based on the average of two short-term tests or the result of the long-term test.
Integrating device:	A device that records, or registers in some manner, information that is directly related to the integral of ambient radon concentration over time within the operating range of the device. Integrating devices include 1) electret ion chambers which are analyzed after the fact by measuring a decrease in electrical potential on the electret, 2) alpha-track detectors which are analyzed after the fact by etching and measuring the track density in a plastic matrix and 3) electronic devices that are not set to, or are incapable of, recording radon concentration in time increments of one hour or less.
HAC Systems:	Heating and cooling (air conditioning) systems that are not designed to also supply fresh air ventilation. HAC systems are common to single-family residences. If they also provide fresh air ventilation, they are more technically referred to as HVAC systems.

HVAC System:	Heating and cooling (air conditioning) systems that are additionally capable of supplying fresh air ventilation. If they do not supply fresh air ventilation, they are more technically referred to as HAC systems.
Measurement professional	(See Radon Measurement Professional)
Mitigation system:	Any system designed to reduce radon concentrations in the indoor air of a building.
Multifamily building:	A building with more than three attached dwellings.
Picocurie (pCi):	One pCi is one trillionth of a curie (10^{-12}) or 0.037 disintegrations per second or 2.22 disintegrations per minute.
Picocurie per liter (pCi/L):	A unit of concentration of radioactivity corresponding to 0.037 decays per second or 2.22 decays per minute in a liter of air or water. 1 pCi/L = 37 becquerels per cubic meter (Bq/m^3).
Quality Assurance (QA):	A complete program designed to produce results which are valid, scientifically defensible, and of known precision, bias, and accuracy. Includes planning, documentation, and quality control (QC) activities.
Quality Control (QC):	The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. Includes calibrations and backgrounds, duplicate, blank, and spiked measurements, inter-laboratory comparisons, audits, and other control activities.
Radon (Rn):	A colorless, odorless, naturally occurring, radioactive, inert, gaseous element formed by radioactive decay of radium (Ra-226) atoms. The atomic number is 86. Although other isotopes of radon occur in nature, in this document, radon refers to the gas Rn-222.
Radon measurement professional:	Any state licensed or nationally certified person or entity that conducts radon testing for remuneration. A professional holds a current radon license from a state where radon testing services are regulated or current national certification recognized by the state in which the test is being conducted. Or, if the testing is being conducted in a non-regulated state, then the professional should have current certification recognized by the non-regulated state.
Relative Percent Difference (calculations):	The relative percent difference between a pair of duplicate measurement detectors is calculated by dividing the difference between the two results by the average of the two results and multiplying by 100. $RPD = [(\vert X_1 - X_2 \vert)/X_{ave}] \times 100\%$ where: X_1 = result of detector 1 X_2 = result of detector 2 $\vert X_1 - X_2 \vert$ = absolute value of the difference between detectors 1 and 2 X_{ave} = average concentration = $((X_1 + X_2)/2)$ Example: $X_1 = 9.0$ and $X_2 = 8.0$ $RPD = [(\vert 9 - 8 \vert)/8.5] \times 100\% = 1/8.5 \times 100\% = 11.8\%$
Relative Percent Error (calculations):	The relative percent error (RPE) is the difference between the known or reference concentration of radon used by a chamber to spike a detector and the resulting measurement value after analysis of the spiked sample, expressed as a percentage of the known

concentration. The RPE may be either a positive or negative number, indicating whether the measured concentration is higher or lower than the known concentration. RPE is calculated by subtracting the known concentration from the measured concentration, dividing by the known concentration, and multiplying the result by 100%.

RPE = (MV – TV)/TV x 100%

where:

MV = measured value of detector

TV = target value of radon chamber

Example:

MV = 11.0 and TV = 10.0

RPE = (11-10)/10 x 100% = 10%

Single family dwelling: A residence or home intended to house a single family and requiring discrete testing location(s).

Spiked Measurements: Spikes are detectors that have been exposed in an approved chamber to a known concentration of radon (i.e. "spiked" with radon). Using spiked measurements can help evaluate the accuracy of a laboratory analysis and/or how accurately detectors supplied by a laboratory measure radon. See Appendix A and Section III for more information.

Standard Operating Procedure: A written document which details an operation, analysis, or action whose mechanisms are prescribed thoroughly and which is commonly accepted as the practice to be followed for conducting certain routine or repetitive tasks.

Test interference: The altering of test conditions prior to or during the measurement in order to change the radon or radon decay product concentrations, or the altering of the performance of the measurement equipment.

Time Sensitive: A measurement strategy that involves a single phase of testing, requiring enhanced quality control measures. Time-sensitive tests include Simultaneous, and Continuous Monitor testing.

Appendix D

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

CHECKLIST FOR SELECTING A SERVICE

Selecting a Measurement Service

1. Contact your State Radon Office (http://www.epa.gov/radon/whereyoulive.html) and request a list of state-licensed radon measurement professionals where applicable or seek professionals certified by either of the two nationally recognized certification programs: The National Environmental Health Association – National Radon Proficiency Program (NEHA-NRPP.org); or the National Radon Safety Board (NRSB.org).
2. Verify the state license (or NEHA-NRPP or NRSB certification) of the professionals conducting the tests and the firms analyzing the detectors by requesting a copy of their current License or Certification Card.
3. Consider checking their references and business history regarding complaints or regulatory actions and any resolutions with your State Radon Office, Better Business Bureau, and State Office of Consumer Protection.

Requesting a Cost Estimate

4. Invite the radon measurement professional to walk through your building(s) before formulating their estimate. Request that they complete *Steps 1 through 4* of Appendix E. These steps serve as a guide for estimating the number of detectors needed and the time that is required to test your building.

Developing a Contract

5. After selecting a measurement contractor, request a contract detailing the terms described in the proposal. Carefully read the contract before signing. Consider including the following in the contract:
   - A limit on the time required to report the measurement (often within 30 calendar days after completion of testing).
   - A description of exactly what work will be done prior to and during the testing period, the time and logistics required to complete the work, and the total cost of the job including all applicable taxes, permit fees, down payment (if any), and terms of payment.
   - A statement that the measurements will meet the standards herein or as recognized by your State, the USEPA, or nationally recognized radon certification program including a statement that they adhere to a QA and QC plan.
   - An outline of the responsibilities of each party in the event that measurements do not fully meet these standards. When the fault is the contractor's, provisions might include re-testing affected dwellings at no cost to the property owner. When the fault is beyond the control of the contractor (i.e. occupants losing detectors, occupant non-compliance, occupants refusing access, etc.) provisions might include a description of possible remedies and related additional expense.
   - A statement that liability insurance and applicable worker's compensation coverage is carried by the organization in the event of injury to persons or damage to property during the measurement process.
   - A statement that the tests will be conducted by state licensed, or nationally certified individuals (as appropriate)
   - A statement that the license or certification number of the individual placing/retrieving the test kits, their signature, and the date will be on the documentation for test results
   - A statement that the contract will be dated and signed by all parties
   - That the contract will be on company letterhead
   - A statement of commitment that copies of the signed contract will be distributed to all signatories
   - A statement of commitment that records of the testing project and the contract will be kept on file for six (or more) years as recommended elsewhere in the standard.

Appendix E

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

PROJECT PLAN: PROCEDURAL CHECKLIST FOR TESTING

The following procedural checklist represents a step-by-step guide for conducting a radon testing program for a Multifamily, residential building. One should be familiar with the issues discussed in SECTIONS II and III of this document before using this checklist. In addition, one should review and understand each section of this checklist before proceeding through the steps.

Planning a Test

1. Develop a floor plan that identifies all the testing locations that are in contact with the ground, are above a crawlspace or as otherwise required herein for test locations. In addition to ground contact plans, floor plans for upper floors will be helpful in selecting the location for the upper floor (10%) requirement. It is recommended that the upper floor test locations be selected so that units on one floor are not directly above or below units being tested on other floors. That will increase the likelihood that the distribution of test detectors identifies pathways for radon migration into upper floors or different batches of building material. Note, the residence manager or head maintenance person may have floor plans available. Identify heating, cooling and ventilation system designs for all testing locations (See 3.6 for further details). If you are unsure as to the type of systems that are present, consult with maintenance personnel, a mechanical engineer or a heating and air-conditioning contractor. You might consider scheduling a time with maintenance personnel to perform a "walk through" of the building complex to identify testing locations.

2. Mark an "X" on the floor plan for areas appropriate for testing.
   a. Note any obstacles that may prevent access or appropriate test conditions. (i.e. Is there a personal lock on door and no key available to open the door?)
   b. Make appropriate considerations for detector placement within the area to be tested.
      - Will you need any special material (e.g. tape, thumb tacks, scissors, string, etc.) to place the detector?
      - What technique(s) will you use to detect tampering?

3. Choose a test strategy that fits your situation (Extended or Time Sensitive Protocols). Take note of quality control requirements for the strategy chosen.

4. <u>Duplicates</u>: Mark a "D" on your floor plan for each testing location expected to receive a duplicate measurement. One duplicate measurement is required for every ten measurement locations unless a 100% duplicate testing strategy has been chosen. See Section III, 4.0 through 4.2 (Extended or Time Sensitive protocols.)

5. <u>Blanks</u>: Account for blank measurements (5% of test locations - See Section III, 5.0 through 5.3 for specific guidance). For example: Randomly mark a "B" on your floor plan for locations that will receive blanks. Avoid placing a "B" in a testing location that already contains a "D". This strategy for recording duplicates and blanks will enable you to intersperse these QC measurements on the log sheets so that the laboratory analyzing your detectors will not be able to identify which recorded measurements are blanks and duplicates. See Exhibit 2 for an example floor plan.

6. <u>Spikes</u>: Account for spiked measurements (See Section III, 2.1.4, 5.0 and 5.4 for specific guidance). For example: Randomly mark an "S" on your floor plan to indicate spiked measurements as required. This strategy will enable you to intersperse these QC measurements on the log sheets so that the laboratory analyzing your detectors will not be able to identify which recorded measurements are spikes.

7. Choose the appropriate device and verify that it is suitable for the times projected for deployment. When selecting the test device vendors, make sure that the reporting and QC expectations will be able to be supported by the company providing the final reports, whether it is a radon measurement professional or testing laboratory. Some laboratories may have preferred chain-of-custody/log sheet formats and processing options (i.e., electronic submission,) so make sure that your record keeping procedures match the capabilities and requirements of the laboratory.

8. Purchase detectors and schedule pre-test QC measurements if appropriate.

Scheduling the Deployment/Retrieval of Detectors

9. Schedule a time with the maintenance personnel for deployment and retrieval of detectors. Provide the number of days that will be needed to deploy and retrieve the detectors so that the maintenance personnel can make the necessary arrangements in their schedules for placement and retrieval at close to 24 hour increments for short term tests.

10. Prepare Resident Notifications (i.e. advance notices for residents, non-interference agreements and "test in progress" signs, etc.)

11. Ensure that reasonable advance notification is provided to residents of the dwelling regarding likely deployment/retrieval dates, required test conditions and other information as appropriate. See Exhibits 5 - 9.

12. Reconfirm your scheduled deployment date(s) and time(s) with the maintenance personnel no later than 2 to 3 days prior to testing.

Preparing Deployment Documentation

13. Prepare log sheets and floor plan drawings.

    - Record the name of the building that you are testing in the space provided on each detector placement log sheet (hereafter, log sheet).

    - Using your floor plan as a reference, record the apartment number or other identifier in the appropriate column of the log sheet for each testing location in the order that you plan to test.

    - For testing locations marked with a "B," indicating a blank detector, record a "B" in the "Room #/Name" column and "Location" column just below the testing location marked with a "B"

      For testing locations receiving duplicate pairs (i.e. locations marked with a "D") record a "D" in the "Room #/Name" column and "Location" column just below the room receiving duplicates. See Exhibit 4 "Example of Data entry: Chain-of-custody / Log" for a sample log sheet.

    - Note the *location* where you plan to place the detector for each apartment or enclosed space.

Deploying the Detectors

14. Before entering a testing location, verify its room number or name with the one on the log sheet.

15. Place the detector and record the detector's serial number in *Serial # column.* Record the date and time of deployment.

16. Place the "Radon Survey In Progress" notice and compliance statement in a conspicuous place. (See Exhibit 7.)

17. Remember to place two detectors or *duplicates* in testing locations preceding a log entry containing a "D". When recording the deployment time for duplicates, consider adding a few minutes (e.g. 2 to 5 minutes) to the starting time so that the laboratory will not know they are duplicates.

18. Though *blank detectors* may not actually be deployed, it is still important to record plausible deployment dates, times and locations for these detectors. (See Section III, 5.0 through 5.3 and Appendix A for more information on blank detectors.)

19. Record the name of the person placing/retrieving test detectors in the space provided at the end of each log sheet.

Retrieving the Detectors

20. When picking up each detector, check its location and serial number with what was recorded during deployment. Note any discrepancies, test interference or non-compliance of required conditions in the *Comments column* of the log sheet. If the serial number does not agree with the one listed, change the number to the "new" one and note the change as a comment.

21. Record the date and time of retrieval in the log sheet for each detector. Do the same for *duplicates and blanks.*

22. Record the name of the person placing/retrieving test detectors in the space provided at the end of each log sheet.

Preparing Detectors for Analysis

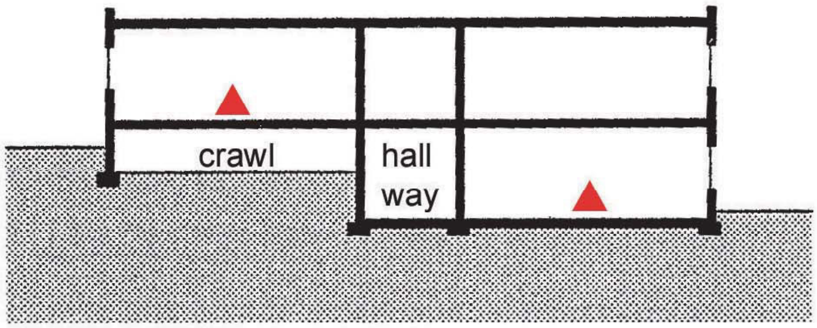
23. The laboratory analyzing the detectors should not be able to recognize *blanks* or *duplicates*. For example, after retrieving the exposed detectors, *blank* detectors must be mixed in with the exposed detectors for shipment. Consult with the manufacturer/laboratory to insure detector-specific procedures approved by the manufacturer/laboratory are used when conducting blank measurements. If appropriate, seals on the blanks might be broken (in some cases, the detector would be opened and immediately closed) and resealed in the same manner as the deployed detectors. Log sheets provided to the laboratory should also obscure which detectors are *blanks* and *duplicates*.

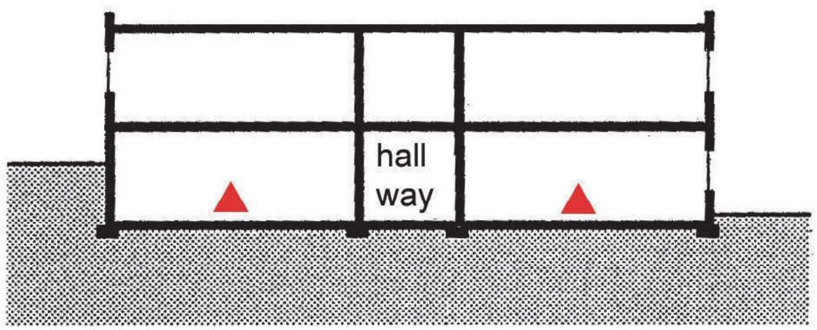
24. Ensure detectors are delivered to the analyzing laboratory within their stated timeframe.

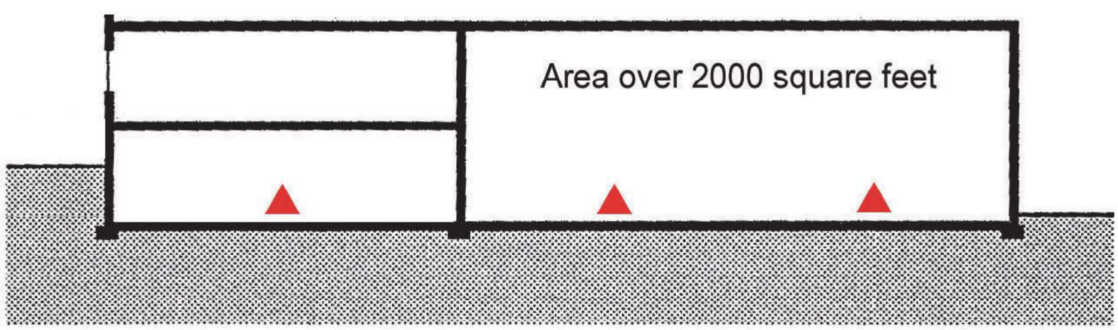
Preparing Report Documents

25. Compile test data into a report form (See Section III, subsection 8).

EXHIBIT 1-a
EXAMPLES: GROUND CONTACT TEST LOCATIONS



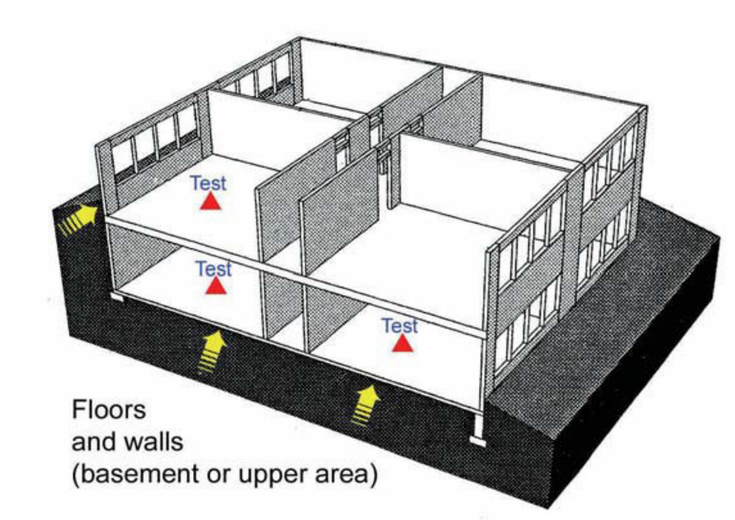


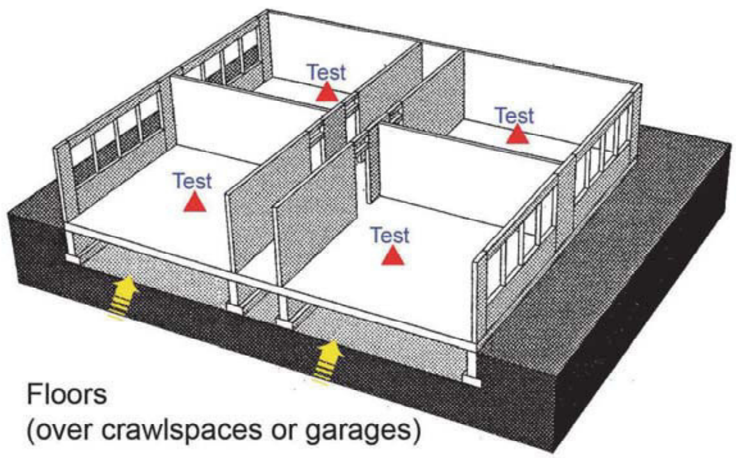


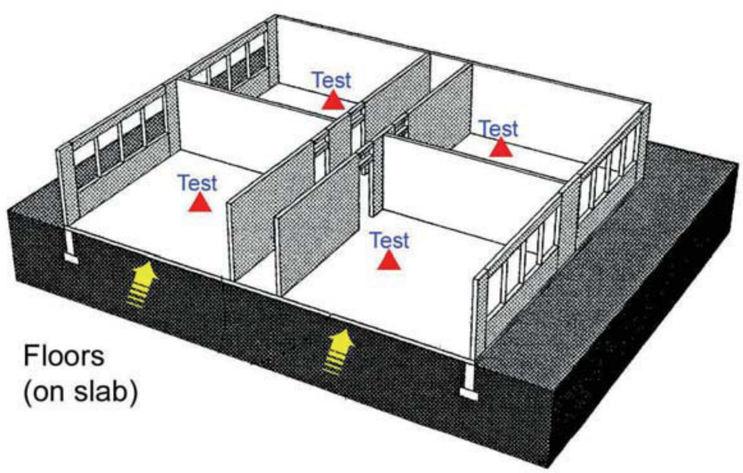
Detectors must be placed at least 20” (50 centimeters) above the floor. For large rooms or open areas – Place one detector every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See Section III, 3.0 “Where to Test” including 3.6 “Choosing a location within a Room” for other details.

EXHIBIT 1-b

EXAMPLES: GROUND CONTACT TEST LOCATIONS

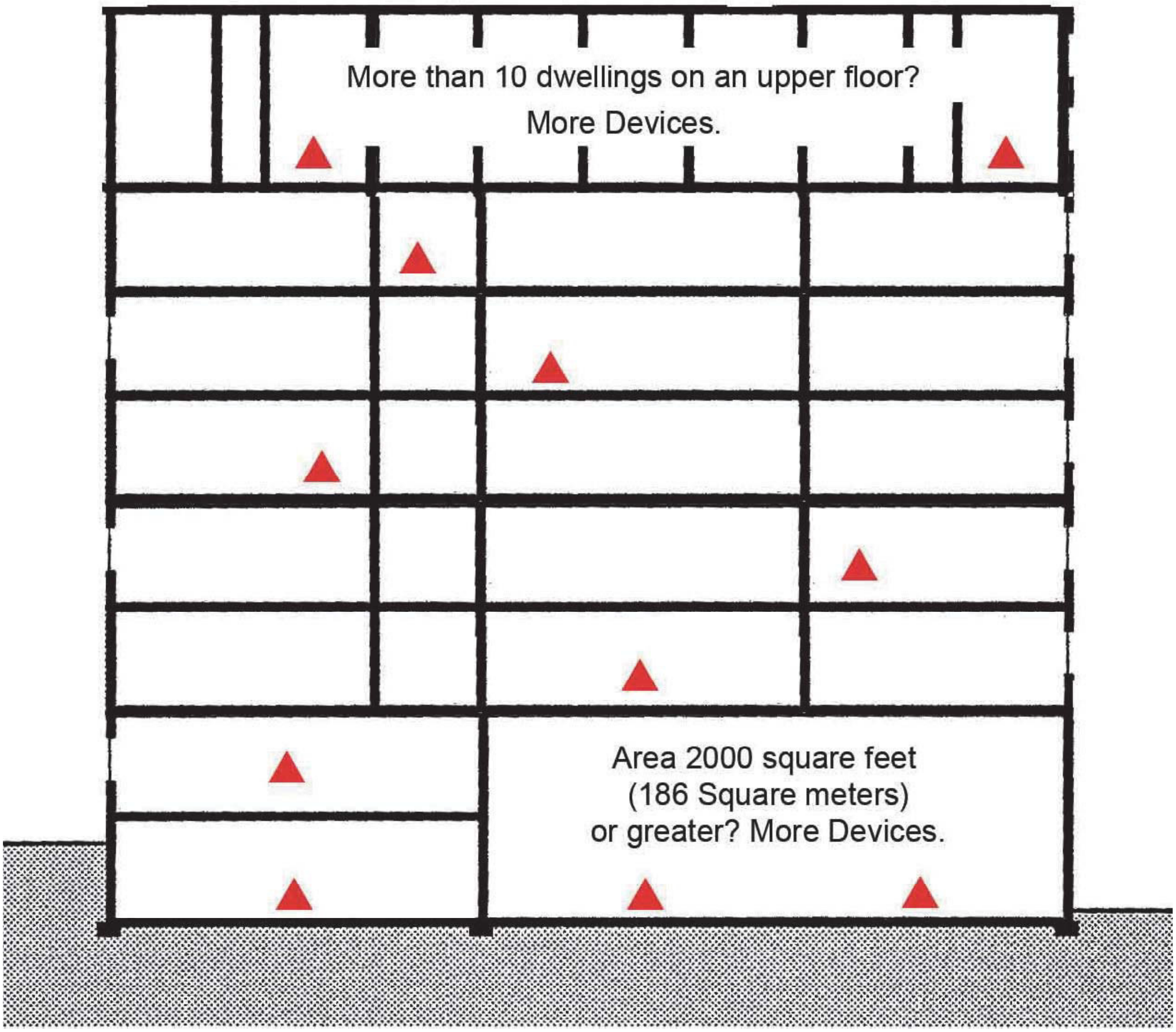






Detectors must be placed at least 20” (50 centimeters) above the floor. For large rooms or open areas – Place one detector every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See Section III, 3.0 “Where to Test” including 3.6 “Choosing a location within a Room” for other details.

EXHIBIT 1-c
EXAMPLE: UPPER FLOOR TEST LOCATIONS



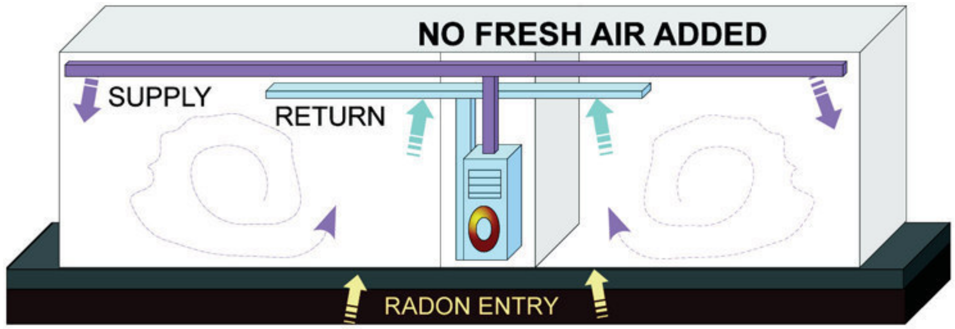
Detectors must be placed at least 20” (50 centimeters) above the floor. For large rooms or open areas – Place one detector every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See Section III, 3.0 “Where to Test” including 3.6 “Choosing a location within a Room” for other details.

EXHIBIT 1-d
HEATING, COOLING AND VENTILATION SYSTEMS:

Group 1: Basic Heating and Cooling:

A dedicated system for each dwelling that does not supply additional fresh air for ventilation.

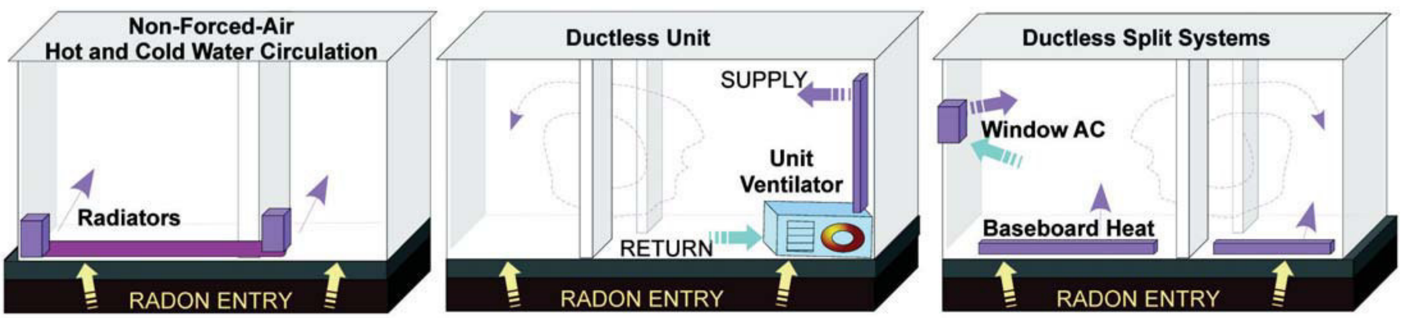
HAC: Many Multifamily buildings have forced-air heating and air conditioning (HAC) systems for each dwelling (such as normally seen in single-family residences) that do not supply additional fresh air for ventilation.



Ductless Systems:

Some Multifamily buildings have dwellings where systems do not have forced-air distribution.

- **Non-Forced-Air Hot and Cold Water Circulation** (sometimes referred to as radiator systems).
- **Window and Unit Ventilators** (sometimes referred to as a through the wall package units).
- **Wall or Baseboard Heating/Cooling Systems.**
- **Ductless Split Systems** with one unit for cooling and another unit for heat (i.e. Window AC for cooling and Baseboard or Wall units for heat).



Group 2: Multi-zone systems

- **Multi-zone systems** are those where different air handlers or systems are employed and independently controlled for different areas within the same dwelling. Such configurations may have been designed originally or added due to modifications of a building or use of an area. Radon concentrations can vary widely room to room based upon variances in system operations.

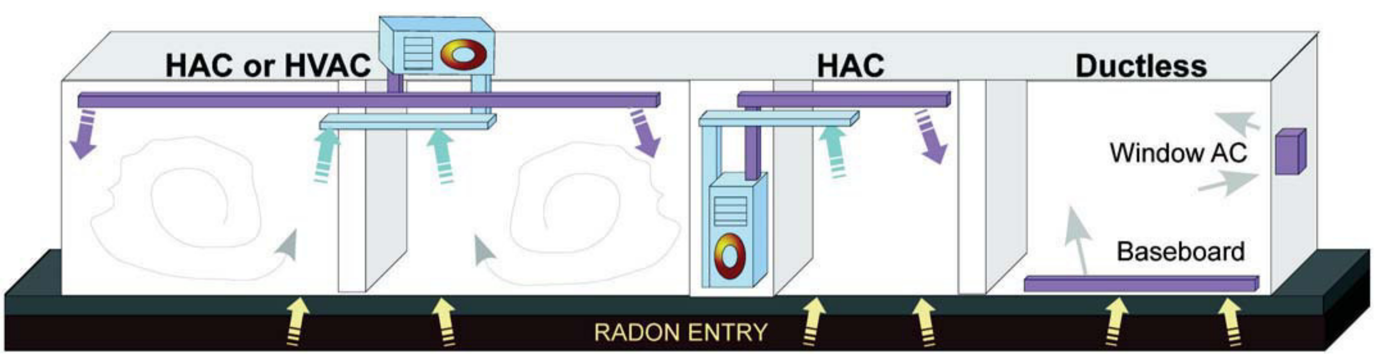


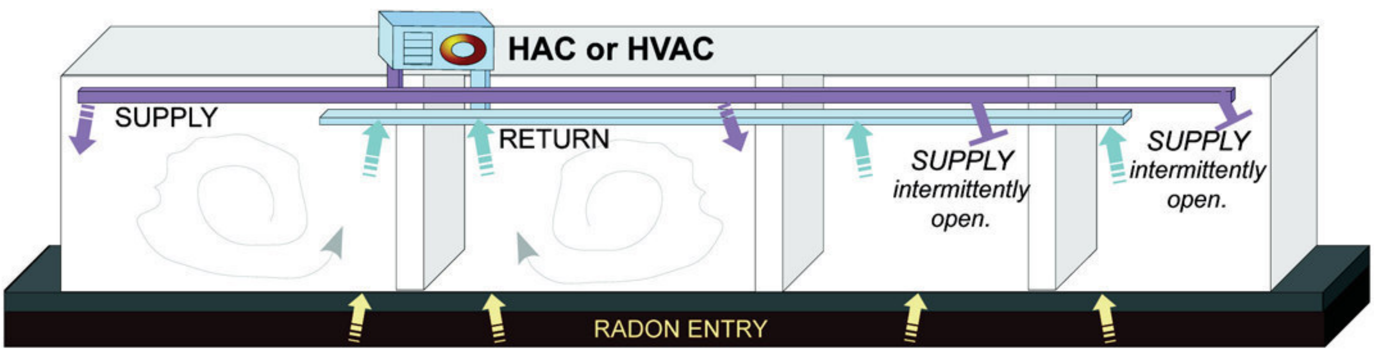
EXHIBIT 1-e

(CONTINUED) HEATING, COOLING AND VENTILATION SYSTEMS:

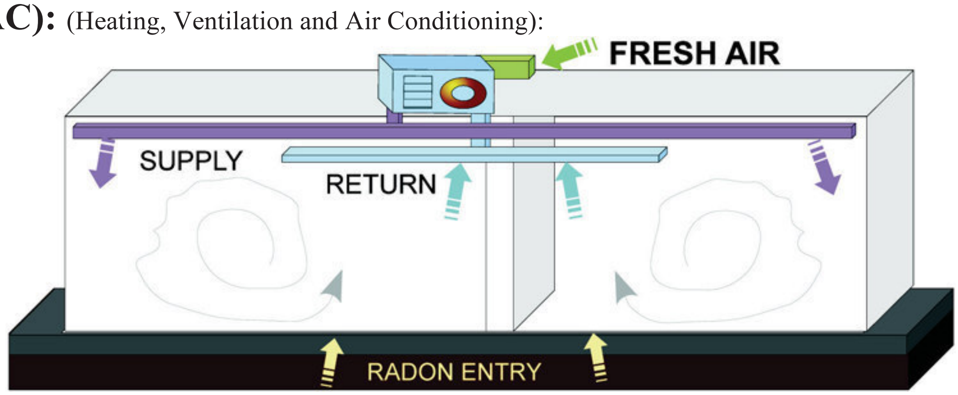
Group 3: Variable Air Distribution and Ventilation

The normal operation of these systems can cause changes in distribution of radon or fresh air ventilation and can also affect pressure relationships that can enhance or diminish radon entry. Depending upon the open or closed operating conditions for supply vents, returns and dilution (if applicable), radon concentrations can vary widely from test to test (or room to room).

Variable Air Distribution: Systems where the airflow from a single air handler is distributed to multiple dwellings or locations with independent controls within each dwelling for duct dampering. Such systems include Variable Air Volume (VAV) systems or systems with fixed volume return vents in each room and controls for dampering supply air.



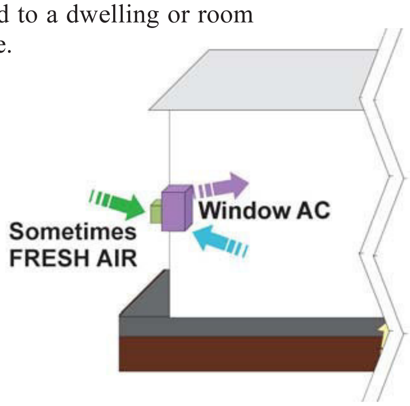
Fresh Air Ventilation (HVAC): (Heating, Ventilation and Air Conditioning):



Some Multifamily buildings have heating, ventilating and air conditioning (HVAC) systems that add fresh air ventilation to dwellings.

Such systems may exist for service to a whole building, multiple dwellings or as single unit ventilators.

Radon concentrations can vary widely from test to test based the volume of fresh air supplied to a dwelling or room at any given time.



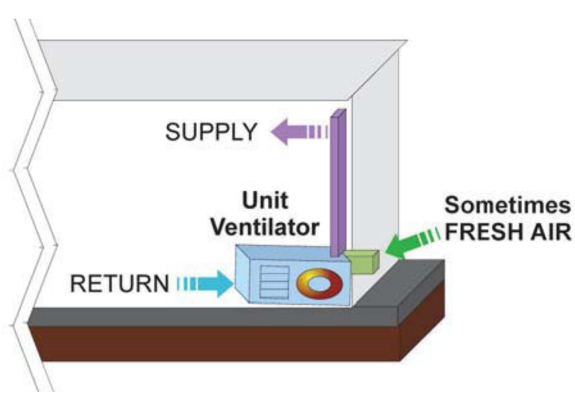


EXHIBIT 2
EXAMPLE: FLOOR PLAN DRAWING/LOG

"X" = Detectors
"D" = Duplicate Detectors
"B" = Field Blank Detectors

Add additional notation as appropriate (i.e. mechanical system notes and continuous or long-term detectors).

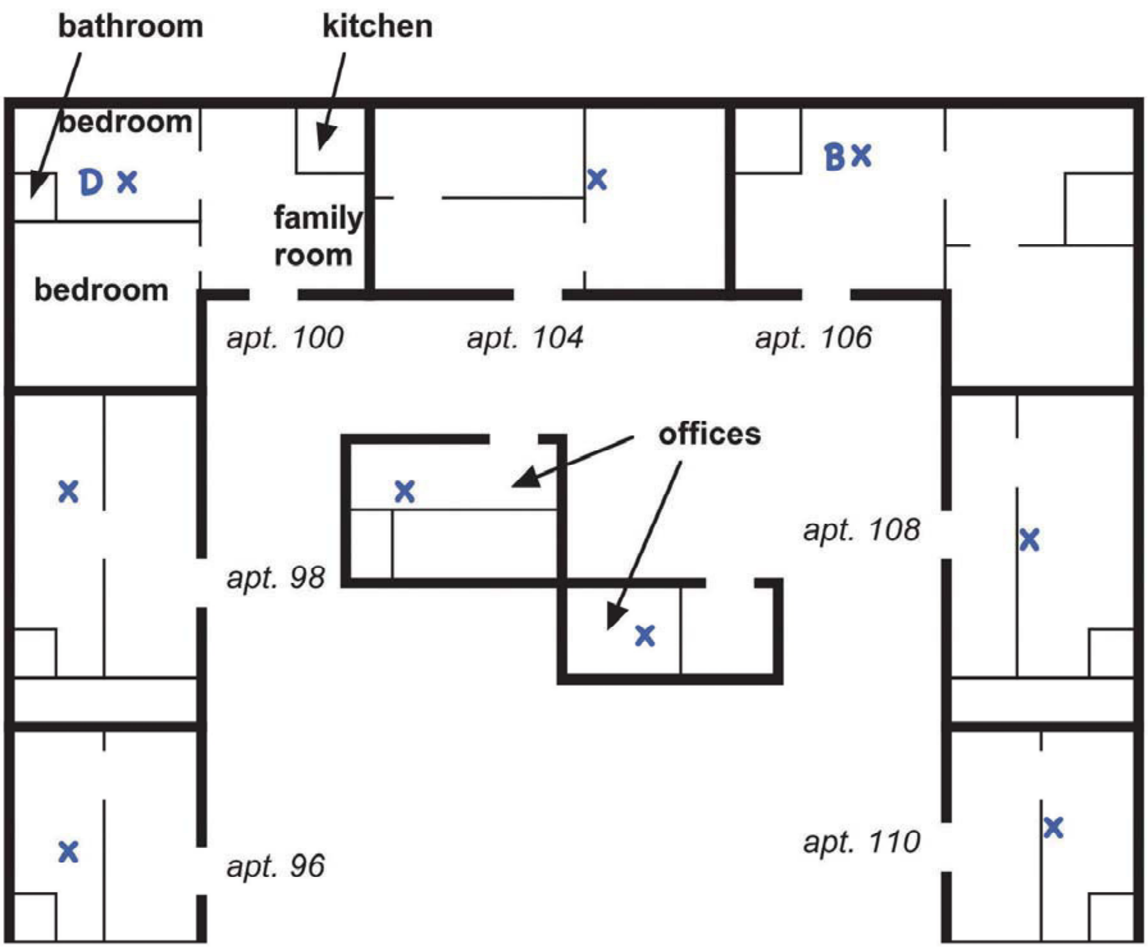


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EXHIBIT 3
SAMPLE: CHAIN-OF-CUSTODY / DATA LOG

This form is an example and not intended to prescribe all manners that may be desired or required for tracking.

Form# _____ / Rev# ________ / Effective Date ________ Management or Radon Company Anytown, USA 800-000-0000

Building Name: ______________________________ **Testing Contractor:** _________________________

Address: ______________________________ **Contractor Phone:** _________________________

______________________________ **Contractor Address:** ______________________________

Contact Name: ______________________________ ____________________________

Contact Phone: ______________________________ ____________________________

Serial Number	Apartment / Room No.	Room	Placement Location	Start Date	Start Time	Stop Date	Stop Time	Floor	Comments	Tech. Place	Tech. PU

Indicate Time Standard used: [ ]AM-PM [ ]Military **Time Zone:** _____________

Technician __________________ Initials ______________ License# ______________
Technician __________________ Initials ______________ License# ______________
Technician __________________ Initials ______________ License# ______________

"D" = Duplicate
"B" = Blank
"S" = Spike

EXHIBIT 4
EXAMPLE OF DATA ENTRY: CHAIN-OF-CUSTODY / LOG

This form is an example and not intended to prescribe all manners that may be desired or required for tracking.

Form# RT1001 / Rev# 2 / Date 09-20-06

Management or Radon Company
Anytown, USA 800-000-0000

Building Name: ______________________________ **Testing Contractor:** ________________________

Address: ______________________________ **Contractor Phone:** ________________________

______________________________ **Contractor Address:** ______________________________

Contact Name: ______________________________ ____________________________

Contact Phone: ______________________________ ____________________________

Serial Number	Apartment / Room No.	Room	Placement Location	Start Date	Start Time	Stop Date	Stop Time	Floor	Comments	Tech. Place	Tech. PU
12345	100	Family	S Wall	2/5/2008	11:00 a.m.	2/9/2008	11:30 a.m.	1		SH	SH
12346	100	Family	S Wall - D	2/5/2008	11:02 a.m.	2/9/2008	11:30 a.m.	1		SH	SH
12347	104	Family	S Wall	2/5/2008	11:08 a.m.	2/9/2008	11:35 a.m.	1		SH	SH
12348	106	Family	S Wall	2/5/2008	11:14 a.m.	2/9/2008	11:37 a.m.	1	D	SH	SH
12349	106	Bedroom	B	2/5/2008	11:15 a.m.	2/9/2008	11:37 a.m.	1		SH	SH
12350	108	Family	N Wall	2/5/2008	11:22 a.m.	2/9/2008	11:40 a.m.	1	Detector was moved	SH	SH
12351	110	Bedroom	Night Stand	2/5/2008	11:25 a.m.	2/9/2008	11:42 a.m.	1		SH	SH
12352	112	Family	Bookshelf	2/5/2008	11:30 a.m.	2/9/2008	11:45 a.m.	1	B	SH	SH
12353	114	Living	N Wall	2/5/2008	11:33 a.m.	2/9/2008	11:50 a.m.	1		GJ	SH
12354	116	Family	E Wall	2/5/2008	11:39 a.m.	2/9/2008	11:53 a.m.	1		GJ	SH
12355	118	Living	E Wall	2/5/2008	11:42 a.m.	2/9/2008	11:56 a.m.	1	D	GJ	SH
12356	120	Bedroom	Dresser	2/5/2008	11:45 a.m.	2/9/2008	12:00 p.m.	1	Window Open	GJ	SH
12357	202	Family	S Wall	2/5/2008	11:55 a.m.	2/9/2008	12:08 p.m.	2		GJ	SH
12358	212	Family	Corner Table	2/5/2008	12:00 p.m.	2/9/2008	12:11 p.m.	2		GJ	SH
12359	306	Living	S Wall	2/5/2008	12:04 p.m.	2/9/2008	12:15 p.m.	3		GJ	SH
12360	318	Bedroom	E Wall	2/5/2008	12:08 p.m.	2/9/2008	12: 18 p.m.	3		GJ	SH
12361	318	Bedroom	E Wall - D	2/5/2008	12:10 p.m.	2/9/2008	12:18 p.m.	3		GJ	SH

Indicate Time Standard used: [X]AM-PM [ ]Military **Time Zone:** Central Daylight

Technician George Jackson Initials GJ License# G100225 **"D" = Duplicate**
Technician Sam Hayes Initials SH License# G107809 **"B" = Blank**
Technician __________________ Initials ______________ License# ___________ **"S" = Spike**

EXHIBIT 5
SAMPLE: NOTICE OF INSPECTION

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower your risk of lung cancer. A radon test is being scheduled for the property.

It is important that we can gain access to place test detectors and that required test conditions are maintained.

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to combustion appliances.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

Tentative detector placement Day _______________ Date______________ Time_________

We will request your signature and any comments on a form left with the test detector.

Tentative detector pick-up Day _______________ Date______________ Time_________

Test detectors are not dangerous in any way and a sample test detector is available for you to examine at _______________. Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office (http://www.epa.gov/radon/whereyoulive.html) or EPA regional office for additional information on radon.

If you have independently conducted radon testing in your residence or have any questions, please contact:
Contact Person: ____Phone: _________________________

We thank you for your cooperation in helping to ensure safe and healthy homes.

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 6
SAMPLE COMPLIANCE STATEMENT

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S**. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.**

An important step is being taken to lower your risk of lung cancer from radon in your home. A radon test is being scheduled for the property.

It is important that required test conditions stated below are maintained.

Please sign this form and add any comments to help ensure accurate tests:

To the best of my knowledge, the required conditions stated below were kept during the test.

Occupant X_________________________ **Date** __________

Address: ______________________________

Comments if any: ____

____

Please leave this form with the test kit or return to: ____________________________

Detector Placed Day__________Date ___________Time______

Detector Pick-up Day__________Date ___________Time______

Required Closed-building conditions

- o Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- o All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- o Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- o Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

For any questions or concerns, please contact: ______________________Phone: ___________

We thank you for your cooperation in helping to ensure safe and healthy homes.

Sincerely,
Management or Radon Company, Anytown, USA

EXHIBIT 7
SAMPLE ONSITE NOTICE OR PUBLIC NOTICE SIGN

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Residents,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S**. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.**

An important step is being taken to lower your risk of lung cancer from radon in your home. A radon test is being scheduled for the property.

It is important that required test conditions stated below are maintained throughout the building.

Test Deployment: Day____________Date __________Time_______

Test Pick-up: Day____________Date __________Time_______

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

If you have independently conducted radon testing in your residence or have any questions, please contact:
Contact Person: ____Phone: _______________________

Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office (http://www.epa.gov/radon/whereyoulive.html) or EPA regional office for additional information on radon.

We thank you for your cooperation in helping to ensure safe and healthy homes.

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 8
SAMPLE NOTICE OF INSPECTION - NONTESTED DWELLINGS

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S. Radon is a naturally occurring radioactive gas that can be present in some buildings at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower the risk of lung cancer from radon to residents in this building. A radon test is being scheduled for the lower floors where radon is normally found.

Radon test detectors will be placed in the lower areas of the building for several days. Other strategic locations may also be chosen. Test detectors are not dangerous in any way and a sample test detector is available for you to examine at _____________. Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office (http://www.epa.gov/radon/whereyoulive.html) or EPA regional office for additional information on radon.

Even though ground contact areas are typically tested for an initial assessment, protocols recommend and encourage that you consider testing your own dwelling for personal verification of low radon exposures. Inexpensive home test detectors are readily available. This can be done during these tests or in the future when the following Closed-building conditions are a normal condition for the building.

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to combustion appliances.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

Even though test detectors may not be placed in your dwelling, it is important that required test conditions are maintained throughout the building.

Tentative detector placement Day______________ Date _____________Time________

Tentative detector pick-up Day______________ Date _____________Time________

We will request your signature and any comments on a form left during the test.

If you have independently conducted radon testing in your residence or have any questions, please contact:
Contact Person: ____Phone: _______________________

We thank you for your cooperation in helping to ensure safe and healthy homes.
Sincerely,
Management or Radon Company, Anytown, USA

EXHIBIT 9
SAMPLE COMPLIANCE STATEMENT - NONTESTED DWELLING

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets. An important step is being taken to lower your risk of lung cancer from radon in your home.

A radon test is being scheduled in the lowest areas of the building. Even though detectors may not be placed in your dwelling, it is important that required test conditions stated below are maintained.

Please sign this form and add any comments to help ensure accurate tests:

To the best of my knowledge, the required conditions stated below were kept during the test.

Occupant X________________________________ **Date** ____________

Address: ______________________________________

Comments if any: ____

____

Please leave this form in an accessible location or return to: _______________________________

Tests will begin: Day_____________Date ______________Time________

Tests will end: Day_____________Date ______________Time________

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

NOTE: Even though ground contact areas are typically tested for an initial assessment, protocols recommend and encourage that you consider testing your own dwelling for personal verification of low radon exposures. Inexpensive home test detectors are readily available. This can be done during these tests or in the future when the above Closed-building conditions are a normal condition for the building.

If you have independently conducted radon testing in your residence or have any questions, please contact:
Contact Person: ____Phone: ______________________

We thank you for your cooperation in helping to ensure safe and healthy homes.
Sincerely,
Management or Radon Company, Anytown, USA

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Deep appreciation is deserved for those who have volunteered long hours for several years towards revision of this document.

Voting members bore most of the weight in review, contributions and deliberation until consensus was achieved. Each personal vantage point contributed unique perspectives to help forge a more perfect document.

With deep appreciation, we honor their names:

Protocol for Conducting Radon and Radon Decay Product Measurements In Multifamily Buildings

AARST CONSORTIUM On National Radon Standards

CHAIR – Trudy Smith

Facilitating Editor – Gary Hodgden

AUTHORIZED CONSORTIUM VOTING DELEGATES

EDUCATORS	Jack Hughes (No alternate at this time)
REGULATED STATES	Cindy Ladage (Patrick Daniels alternate)
NON- REGULATED STATES	Jim McNees (Adrian Howe alternate)
PROFICIENCY PROGRAM	Shawn Price (Angel C. Price alternate)
HOME INSPECTORS (ASHI)	Steve Gladstone (Tim Tucker alternate)
MEASUREMENT PROFESSIONALS	William Levy (Debbie Kalina alternate)
MITIGATION PROFESSIONALS	Dave Wilson (No alternate at this time)
Manufacturer	Martin Smith (Carolyn K. Allen alternate)
Chambers	Phillip H. Jenkins (James Burkhart alternate)
Federal: EPA (non-voting)	Phil Jalbert (No alternate at this time)

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AARST CONSORTIUM ON NATIONAL RADON STANDARDS
www.radonstandards.us
standards@aarst.org

WWW.AARST.ORG